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A REAL CHIEF ENGINEER

La Salle Plant Saves $45,000 Annually

By Thomas Wilson

SYNOPSIS—By intelligent supervision, the stopping of steam leaks to the atmosphere, and remodeling the boiler furnaces so that evaporation was increased 60 per cent., this enormous saving over the previous cost of operation was effected.

In 1909 the power plant in the La Salle Hotel, Chicago, was put into commission. It was equipped with good machinery and was well laid out, but unfortunately it was not operated efficiently—in fact, the operating costs were so high that at one time central-station current was seriously considered. A new engineer, W. W. Bird, came to the rescue, and as he was backed by a progressive manager, Ernest J. Stevens, who came on about the same time and incidentally has increased the business of the hotel 30 per cent., an enormous saving was made in the operating expenses.

For the year 1913, the total power-plant costs were $43,000 less than in 1910 or in 1911, and in the present year further reductions averaging between $200 and $300 per month are being made. If the results obtained in the next few months are as good, the total annual saving over the previous cost of operation will exceed $45,000 per year. This is an enormous figure, large enough to operate a power plant in any ordinary building.

In a hotel, however, there are many and varied services. The elevator load is heavy and so is the lighting; enormous quantities of hot water and steam are required, the heating and ventilation demands are usually excessive and refrigeration is needed for the kitchen, for cooling some of the larger rooms and for making ice. Then there are compressed air uses and vacuum cleaning machines, and plumbers are a necessity on the operating force. Besides, there are other services calling for men and machines, so that it will not be surprising to learn that the operating cost under the original management mounted as high as $138,000 per year. At present it is below $95,000 and for the services rendered is not excessive.

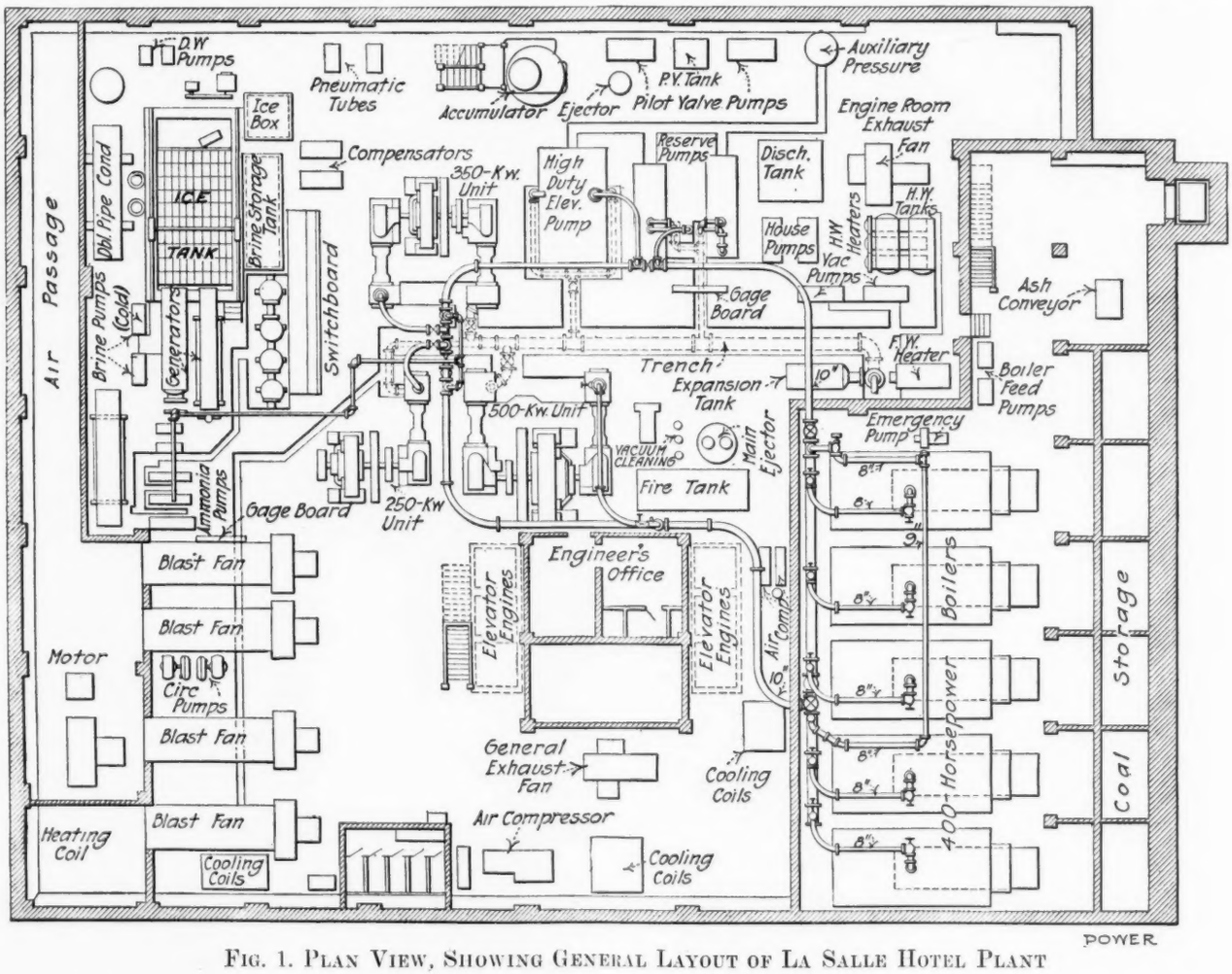


Fig. 1. Plan View, Showing General Layout of La Salle Hotel Plant

Power-Plant Equipment

It will be interesting to learn how this great saving was made, but first it will be well to know the equipment of a plant which consumes on the average 100,000 lb. of coal and 450,000 gal. of water per day of 24 hr.

The hotel is 22 stories high, measures in plan 162.5x178 ft. and contains 1172 rooms. The plant occupies the sub-basement; its general layout is shown in Fig. 1. There are five 400-hp. combination fire and water-tube boilers, which are served by chain-grate stokers, and originally there was a large ash-storage capacity at the end of the grates. At this point a special dump box was provided.

In generating capacity there is a total of 1100 kw., made up by three directly connected units. The largest has a capacity of 500 kw. and the prime mover is a cross-compound engine with cylinders measuring 20 and 32x36 in. Another 17 and 28x30-in. cross-compound engine drives a 350-kw. generator, and the third is a 250-kw. unit with a simple 19x30-in. engine. Direct current is generated and distributed at 110-220 volts on the three-wire plan. The normal load averages close to 400 kw., while the connected load is about 900 kw.

Heating in the smaller rooms is effected by direct radiation, while in all the large rooms, dining rooms, banquet halls, etc., the heating is indirect. An extensive system of ventilation replaces the air of the entire building every six minutes. In the summer, cool air is supplied to the public rooms and banquet halls by a 100-ton absorption refrigerating system. A similar outfit rated at 50 tons makes on an average for the year 10 tons of ice per day, and cools the drinking water and 53 refrigerators. These systems use exhaust steam from the auxiliaries at a pressure of ½ lb. to 15 lb. above the atmosphere.

There are six hydraulic passenger elevators and three for freight, the pumping equipment consisting of a three-cylinder compound Corliss, high-duty, 13, 16 and 16x41¼x13-in. pumping engine, one high-duty, 18½, 22 and 22x53¼x24-in. pump, and a simple 12x18x43⅜-in. pump. Then there are the boiler-feed, vacuum, brine and house pumps, heaters and other auxiliary equipment described more in detail in the May 17, 1910, issue of POWER.

How Saving Was Made

When the new engineer took charge, there were 22 steam traps in the building. Upon investigation, it was found that all of them leaked. A large quantity of live steam was constantly escaping to the exhaust and most of it eventually to atmosphere. These traps were replaced by eight of greater capacity and of a type which by their movement gave evidence of satisfactory operating conditions. An important leak was stopped and the engineer gave his attention to the operating schedule of the main units.

Fig. 2 shows how the electrical load varied on an average day of 1910 or 1911 and how at different periods it compared with the capacity of the three generating units. Formerly it had been the custom to run unit No. 3 from 7 a.m. to 5 p.m., units Nos. 1 and 2 from 5 p.m. to 1 a.m. and No. 1 for the balance of the time. As the load curve will show, there was no occasion to run two units at any one time and a more economical schedule was possible. It did not take long to decide that it would be better to run No. 2 from 7 a.m. to 5 p.m., No. 3 for the heavy load from 5 p.m. to 1 a.m. and No. 1 for the balance of the night. This schedule has been maintained for the past two years and has resulted in a considerable saving in steam.

A revision of the various fan-motor schedules and a change from arc to tungsten lamps in the basement, resulted in a lower kilowatt output, although 820 twenty-five-watt tungsten border lamps had been added at the

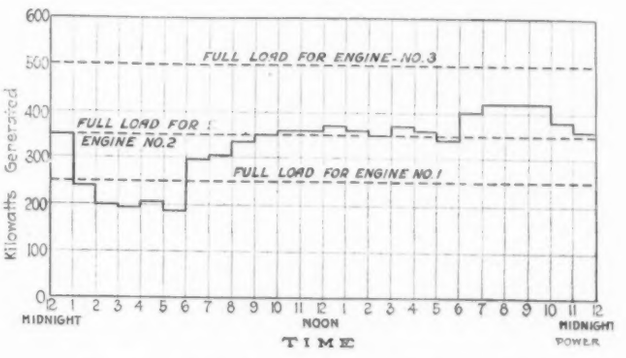


FIG. 2. LOAD CURVE FOR TYPICAL DAY

fourth floor, 1350 ten-watt sign lamps on a large roof sign and a number of motors in the laundry, kitchen and new machine shop increased the connected load. Besides, a general overhauling of the steam-using equipment and the change in the schedule of the main units reduced the steam consumption so that instead of an excess of exhaust steam—which had always been the case in the past, even in winter—live steam is now needed when the temperature outside falls below 20 deg. F. Weather at this temperature occurs only a small percentage of the heating season, so that during the greater part of the colder months the plant is working under ideal conditions.

The ice-making plant was also perfected and its capacity so increased that $300 worth of ice was bought in 1913, as compared to $2400 in 1911. A comparison of the tonnage is available in Table 1; in Table 2 is given the cost of purchased ice.

Greatest of all was the saving made in the coal pile by a modification in the boiler settings. Fig. 3 shows the

TABLE 1. A COMPARISON OF OUTPUT AND COAL

Months	Tons of Coal		Cost of Coal		Kw.-Hr. Light and Power		Ice Made, Tons		Cost Removing Ashes	
	1910	1913	1910	1913	1910	1913	1910	1913	1910	1913
March	2,190	1,395	$6,398.14	$3,523.93	272,830	231,100	193	262	$454.00	$141.50
April	1,888	1,206	5,996.56	3,071.62	218,160	218,460	208	259	406.00	158.50
May	1,880	1,276	6,073.68	3,222.44	244,570	222,890	234	348	352.00	157.50
June	1,770	1,164	5,728.99	2,945.42	253,010	214,490	249	368	400.00	145.57
July	1,769	1,233	5,407.01	3,115.92	218,910	211,740	248	412	408.00	136.58
August	2,068	1,250	6,205.05	3,159.09	306,970	220,485	254	419	458.00	145.13
September	2,023	1,298	6,059.35	3,198.62	307,110	219,070	246	318	481.65	164.47
October	1,780	1,365	5,338.20	3,471.41	210,130	235,000	248	297	270.05	164.70
November	1,718	1,278	5,156.40	3,229.66	279,680	228,250	213	278	202.00	148.95
December	2,032	1,345	5,913.45	3,400.38	248,570	231,590	226	268	300.00	143.60
January	2,085	1,429	5,805.00	3,611.53	320,910	243,300	226	261	379.00	159.30
February	1,623	1,338	4,706.85	3,387.58	300,000	220,070	211	232	242.00	159.30
Totals	22,826	15,577	$68,788.68	$39,337.60	3,180,850	2,696,445	2,756	3,722	$4,352.70	$1,825.10

TABLE 2. A 4-YR. SUMMARY OF OPERATING COSTS

Items	1910	1911	1912	1913
Wages	$35,885.08	$36,249.05	$35,196.58	$35,573.62
Maintenance and supplies	19,219.36	21,314.65	12,908.63	9,649.94
Coal	68,788.68	65,208.50	50,697.23	39,337.60
Ice bought	2,100.00	2,409.50	396.50	286.74
Water	11,800.00	12,844.53	11,512.50	9,908.35
Total	$137,793.12	$138,026.23	$110,711.44	$94,756.25

old arrangement. Space had been left between the end of the grate and the bridge-wall for a perforated dump box extending the full width. This box had considerable capacity and by collecting the ashes gave time for the incandescent particles carried over to give up most of their heat before being dropped into the ashpit. From this box a wedge-shaped piece projected to raise the clinker from the grate, so that it would not clog the delivery of the finer ash. The intention was good, but the result was the continual breaking of links.

As regards combustion, the air naturally took the course of least resistance, passing along under the grate to the perforated dump box at the rear or to the same spot through the plank covering the mouth of the ashpit, as indicated by the arrows. Very little of it passed through the fuel bed where it was needed, the greater quantity taking the longer but easier course through the dump box at the rear. An evaporation not exceeding 5 lb. of water per pound of coal was obtained and the average could not have been much over 4 lb. It was impossible to burn No. 5 coal, a mixture of Nos. 3 and 4 Carterville washed coal being the fuel used.

The revised furnace is shown in Fig. 4. Iron doors replace the plank flooring. Partitions in the ashpit and under the grate force the air to pass up through the fuel. The dump box was taken out and the bridge-wall carried over as shown, with a water-back to support it and at the same time better the circulation in the boiler. The result is an evaporation of 8 lb. of water per pound of coal, and the fuel burned is a mixture of Nos. 4 and 5, which can be obtained at a lower cost per ton. Now there are no leaky tubes at the back head, a common occurrence after a shutdown in the old days.

Ashes were formerly wheeled to a chute leading to the underground freight tunnel, dumped in a space provided for the purpose and then shoveled into the tunnel cars. These two handlings were reduced to one by having the ashes carted away and the cost per month to remove them was lowered from an average of $360 to $150.

Comparative Records

Table 1 compares the tonnage and cost of coal, the load, quantity of ice made and the cost of removing ashes for

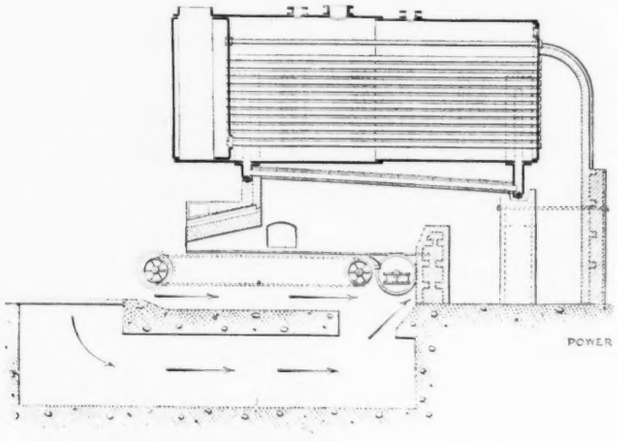


Fig. 3. Original Furnace Design

1910 and 1913, the fiscal year starting in March and ending in February. Only the figures for these years are given, as the results for 1909 and 1911 are much the same. This also applies to Table 2, which is a summary of the operating costs for the four years the plant has been in operation. During 1912 the plant was being put in condition, and although a saving was made over the previous years, it is not as large as in 1913.

The totals in Table 1 show that the saving in coal alone was $29,451.08, due to burning less by 7249 tons and to a lower cost per ton, as by remodeling the furnace it was possible to burn a mixture of Nos. 4 and 5 instead of Nos. 3 and 4. The load is less by 484,405 kw.-hr. per year and the cost of removing ashes has been reduced $2527.60. In the ice plant the increase in output is 966 tons.

Table 2 is a summary of the operating and maintenance

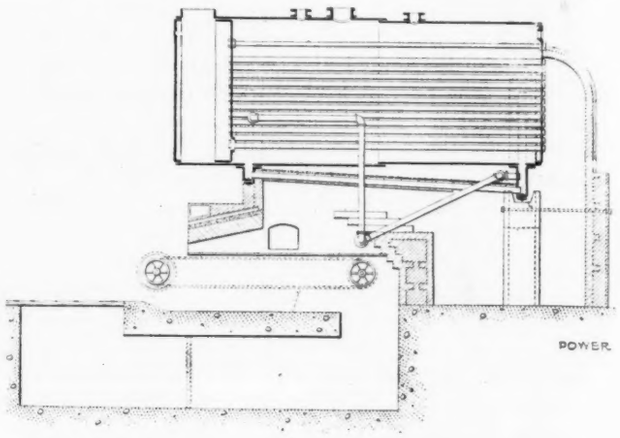


Fig. 4. The Improved Furnace

costs of the entire engineering force of the building from 1910 to 1913. Under the former management these costs averaged close to $138,000. In 1913 they were reduced to less than $95,000, the exact difference between 1911 and 1913 being $43,269.98. From March 1 up to the present writing there has been a further reduction of from $200 to $300 per month, so that for 1914 the saving over 1911 should exceed $45,000.

It should be borne in mind that the business of the hotel has increased 30 per cent., and ordinarily a corresponding increase would be expected in the demands on the engineering department. The showing made by Mr. Bird is then all the more creditable. It is an indication of what attention to business will accomplish in a power plant. Getting after the small leaks as well as the big ones, using rare judgment in arranging the operating schedules of the main units and auxiliaries and keeping all apparatus in first-class condition are the things that count. Add to these a good system of records showing the results obtained and an engineer who can properly interpret them, and you have in a nutshell the correct explanation of the remarkable showing made in the La Salle Hotel plant.

Repairs to Valves—The repairs to valves in boiler plants may be facilitated by the use of one make of valves throughout the piping system. This involves the keeping in stock of but one kind of repair parts, with which the steamfitter soon becomes familiar.

Canadian City Takes Over Utilities Plant—Sault Ste. Marie, Canada, has taken over the Tagona Water & Light Co. The employees of the former water and light company will be on the city payroll under the supervision of the water and light committee.

The rates will be based on their schedule as per 100 ft. of floor space. It is the intention of the city to do away with the meter rental, which has been a source of contention in many places.

New Rotary Air Compressor

An air-cooled rotary air compressor, which at 400 r.p.m. makes 3200 compressions per minute to deliver about 75 cu.ft. of air at 100 lb. pressure, has just been placed on the market by the Wernicke-Hatcher Pump Co., Grand Rapids, Mich.

The machine, shown in Fig. 1, weighs only 1400 lb. It is 46 in. long, 28 in. wide by 35 in. high, and is arranged for belt drive. It consists principally of two elements, a rotor and a rotor casing, both of which revolve in the same direction and at the same speed on independent axes eccentric to each other. Plates extending radially from the rotor and fitting into slots in the casing and case heads, divide the displacement of the compressor into eight independent pockets. The plates are pivoted to shoes which slide on the surface of the rotor. To allow for the eccentricity and maintain a permanent seal between pockets, the plates slide back and forth in the slots, but as the elements rotate in the same direction, the movement of the plates is relatively slow. This permits a close sealing fit on the side walls, and as the pressure in the leading pockets during compression is always greater than in the pocket behind, the plates are pressed down on the faces of the slots so that there is no leakage back to the chambers of lower pressure.

The operation may be explained by the use of Figs. 3, 4 and 5, in which for simplicity the pockets have been reduced to four. These illustrations show the successive positions taken by the compressing elements, while the compressor revolves through one-fourth of a revolution. In the Fig. 3 pocket, *A* is fully contracted and has just discharged its volume of air. Pocket *B* is sucking in air, *C* is filled with air and *D* is compressing. In Fig. 4, *A* has begun to take in air, *B* is still taking it in, while

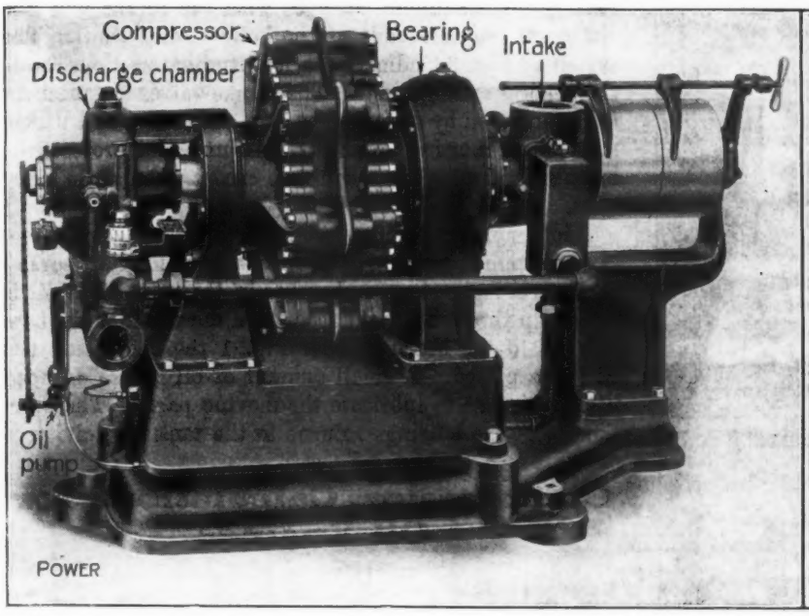


Fig. 1. Wernicke-Hatcher Single-Stage Rotary Air Compressor

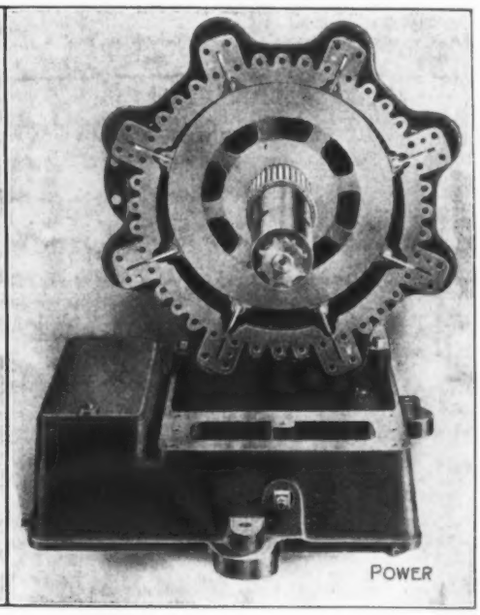


Fig. 2. Discharge End with Rear Bearing Bracket and Case Head Removed

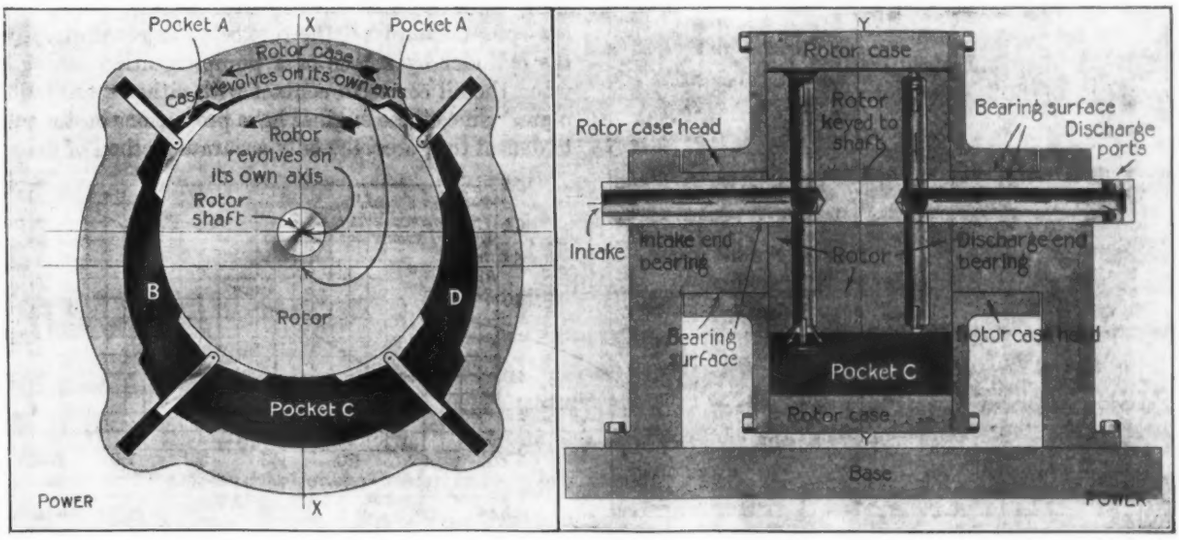
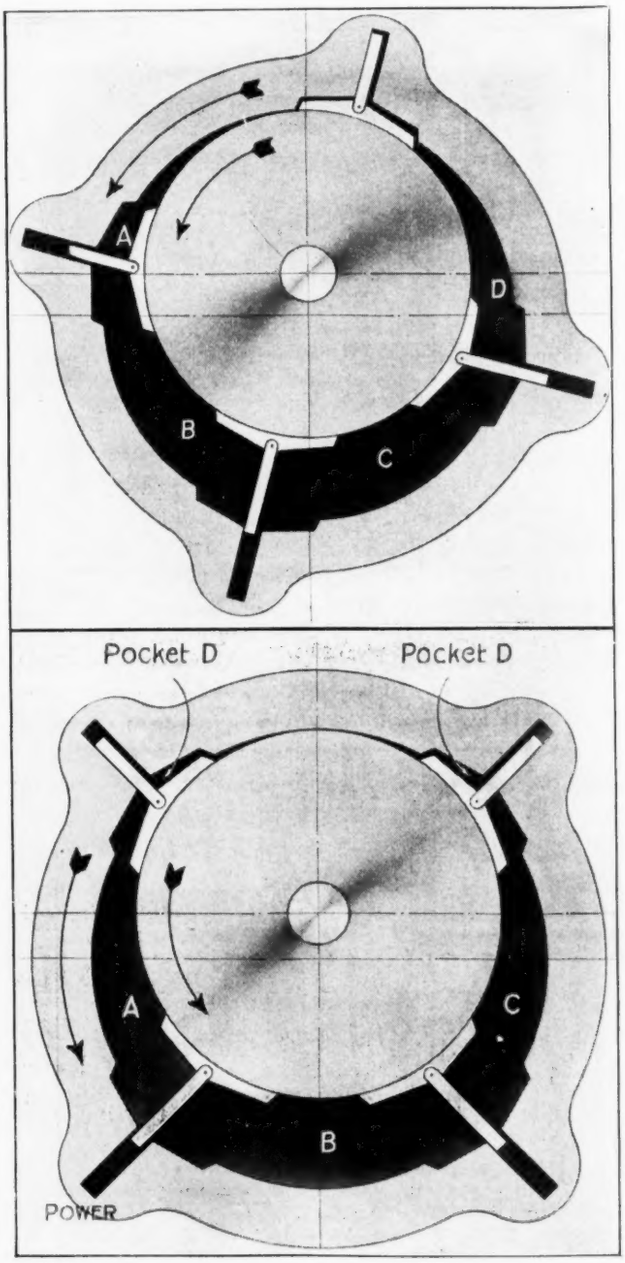


Fig. 3. End and Side Sectional Views, Showing Positions Taken by the Elements

C has begun to compress and *D* has compressed still further. In Fig. 5, *A* is still drawing in air, *B* has been filled, *C* is still compressing and *D* has discharged its air. It will be apparent that as each pocket passes from the position *A* to *C*, Fig. 3, or through one-half revolution, it expands and draws in air. Through the second half of the revolution, it compresses this air and discharges it.

With eight pockets there is practically continuous compression. The periods of operation overlap so that the air



FIGS. 4 AND 5. SHOWING POSITION TAKEN BY THE COMPRESSING ELEMENTS

is discharged uniformly at the desired pressure. This gives a steady torque on the drive shaft, and as the machine is equipped with roller bearings the friction is low. From Fig. 2 it will be evident that the clearance volume in a closed pocket is small, and another feature is the cooling surface afforded by the rotor casing. In proportion to the volume of air compressed, this surface is unusually large, and is not reduced during compression. On this account, much of the heat of compression is radiated, and on an all-day run it is reported that the temperatures will not exceed 300 deg. F. Water cooling is not necessary. The even load and easy starting permit direct connection to a high-speed electric motor with automatic starting and stopping under load if desired. This feature conserves the energy for driving, as the machine is at rest except when air is actually used.

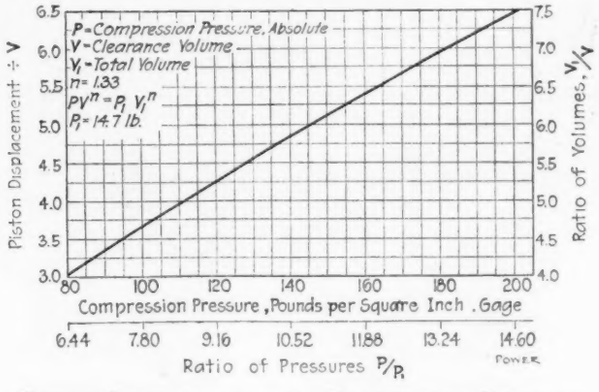
Each pocket is provided with an intake and a discharge valve. Both are of the ordinary poppet type, and connect through suitable passages with the intake and discharge at opposite ends of the hollow rotor shaft. The sketch in Fig. 3, indicating a longitudinal section, shows the general arrangement. The intake valves are mechanically operated by a stationary cam, the valves and lifting mechanism rotating around it. An unloader protects the machine and allows it to run idle except when air is being used.

Another feature of the compressor is the oiling system. A small pump, chain driven from the main shaft, draws oil from a large storage chamber in the base. The oil is forced up through a sight feed, then down under the base and up to the bearings. In Fig. 1 the sight feed has not been placed. A small amount of oil is also dropped into the intake to lubricate the moving parts. The overflow from the bearings returns to the tank by gravity.

Compression Calculations for Oil Engines

By D. O. Barrett

The writer recently had occasion to make extended tests covering the determination of compression and the relation existing between the compression pressures and volumes in oil engines. The engines on which the tests were made were of the two-stroke-cycle, semi-Diesel or low-compression type, the fuel being injected directly into the cylinder by means of a pump, ignition taking place when the oil comes in contact with either a hot bulb or a plate. Since these engines have projections on the pistons, to deflect the gases, the only accurate method of determining the compression volume was by filling the clearance space with water, previously measured, and this was done in all cases. In some instances, however, a definite amount was faced off the cylinder head to decrease the compression and in these cases the volumes could easily be calculated from previous measurements; in other cases, plates were used between the cylinder head and the cylinder to increase the compression volume.



PISTON DISPLACEMENT VS. COMPRESSION PRESSURE

The effective piston displacement is represented only by that portion of the stroke to the edge of the exhaust ports, and this is one reason why two-stroke-cycle engines do not produce a greater percentage of power in comparison with the four-stroke-cycle, since about 15 per cent. of the stroke is lost, due to the uncovering of the exhaust ports.

From low-spring indicator diagrams, it was found that atmospheric pressure was reached on the compression stroke when the piston had just covered the exhaust ports. The engines tested covered a variety of sizes ranging from 10 to 100 hp., and with piston speeds varying from 600 to 900 ft. per minute. It was found, however, that the variation in the piston speeds had no appreciable effect upon the compression pressures.

The relation between pressures and volumes is represented by the following:

$$PV^n = P_1 V_1^n \text{ or } \frac{P}{P_1} = \left(\frac{V_1}{V}\right)^n$$

where,

$P_1 = 14.7$;
P = Compression pressure absolute;
V = Clearance volume;
V_1 = Total volume.

The accompanying table shows the results obtained

VALUES FOR P and n for DIFFERENT ENGINES

Bore	Stroke	Compression Pressure Lb. per Sq.In. P	Value of Exponent n
9	12	105	1.27
10	15	98	1.33
10	15	110	1.29
10	15	134	1.32
10	15	170	1.31
11	16	115	1.29
11½	16	108	1.26
14	16	118	1.35
14	18	126	1.32
14	18	134	1.35
14	18	144	1.32
16	24	155	1.37

from these tests, giving the bores and strokes of the engine, together with the compression pressure, also the value of the exponent n in the above equation. It will be noticed that these values vary from 1.26 to 1.37, the average being close to 1.33. From the tests it would seem safe to accept the value of 1.33 for compression calculations in this type of engine. This value, which is equivalent to 4/3, greatly simplifies compression calculations which, at best, are somewhat difficult for the average engine designer. Tables of squares and cubes are readily obtainable, while the fourth root may be obtained by taking the square root of the square root.

As an example, assume an engine cylinder of 16-in. bore and 20-in. stroke, the distance from the end of the cylinder to the edge of the exhaust port being 85 per cent. of the stroke, or 17 in. The area of a 16-in. circle is 201.06, which, multiplied by 17, gives 3418 cu.in. as the effective piston displacement. It is desired to carry a compression pressure of 135 lb. gage, which would make the absolute pressure 149.7 lb., while the pressure at the beginning of the stroke is 14.7 lb.

We now have:

$$P_1 = 14.7; P = 14.7 + 135 = 149.7$$

$$\frac{P}{P_1} = \frac{149.7}{14.7} = 10.18$$

$$V_1 = 3418 + V$$

Now,

$$\frac{V_1}{V} = \sqrt[n]{\frac{P}{P_1}}$$

or

$$\frac{3418 + V}{V} = \sqrt[4]{(10.18)^3} = 5.69$$

$$(5.69 - 1)\ V = 3418$$

or

$$V = \frac{3418}{4.69} = 728 \text{ cu.in.}$$

as the volume of the compression space.

The accompanying curve shows graphically the relation between the pressure and volume ratios. Compression pressures are given at the bottom, since it may be safely assumed that the pressure at the beginning of the compression stroke is atmospheric. At the left is given both the ratio of the compression volume to the total cylinder volume, and also to the piston displacement, the latter value being one less than the former.

Ellison Differential Draft Gage

The inclined-tube differential draft gage, first brought out by L. M. Ellison, of Chicago, in 1896, formerly was made in the open type only, but more recently an inclosed type, with a glass cover to show the scale and the inclined tube in which oil is used as the indicating medium, has been added to the line. The liquid movement is

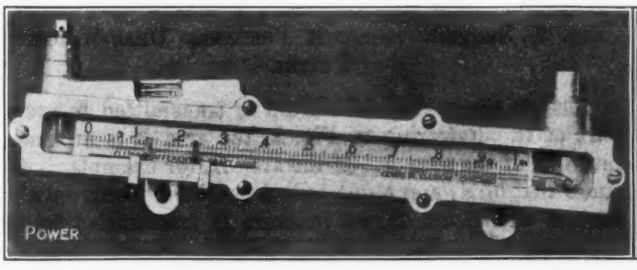


FIG. 1. COVER-TYPE DIFFERENTIAL DRAFT GAGE

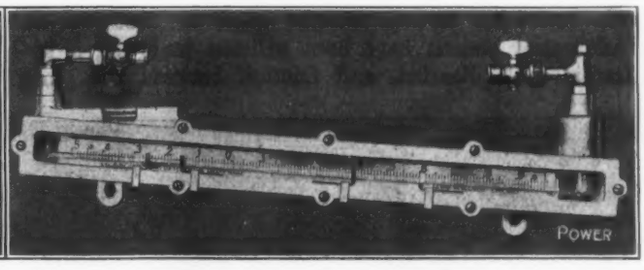


FIG. 2. COMPOUND DIFFERENTIAL DRAFT GAGE

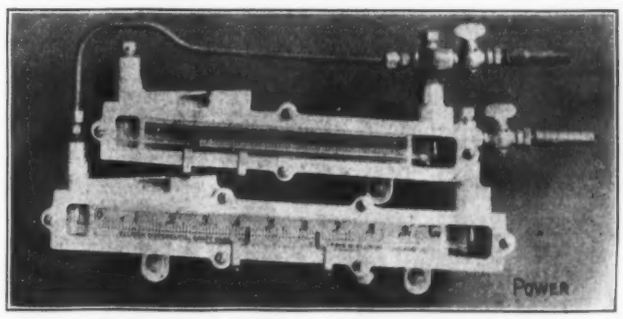


FIG. 3. MULTIPLE DIFFERENTIAL DRAFT GAGE

multiplied five, ten or fifteen times. The 1914 model, Fig. 1, is of heavy construction and as an innovation has a pair of movable pointers, which are attached to the cover frame and may be set to indicate an economical range of draft for given variations in load and fuel bed.

Fig. 2 shows a new single-tube compound gage which multiplies the liquid movement ten times. The scale reads on both sides of zero, on the chamber end indicating the draft at the breeching, or indirectly variations in the air supply, and at the indicating-tube end of the gage the draft at the furnace. When both cocks are closed, the two tube ends are vented to the atmosphere through openings in the cocks, and the liquid stands at zero. To indicate the furnace draft only, the cock at the indicating-tube end is opened, and the cock at the other end for the draft at the breeching; as with a single tube only one reading at a time can be taken. It is usual to run the gage continuously on the chamber end, which is connected to the breeching, and use the draft or furnace side only as a check in case of soot stoppage. Pointers limiting the economical range for either reading are provided.

A third gage, which has just been perfected, is the multiple differential gage shown in Fig. 3. This consists of two cover-type gages mounted on a cast-iron plate and cross-connected with copper tubing. The upper gage continuously indicates the furnace draft, and the lower gage the variations in the air supply by the drop in pressure between the flue and the furnace. As the gages are independent of each other, they can be equipped with scales which magnify equally the liquid movement, or one may magnify ten and the other fifteen times. For light draft and low drop, such as is found in oil burning, the larger scale is of special advantage. The several types mentioned and other gages modified for special work can be furnished either "right or left" by Lewis M. Ellison, 6238 Princeton Ave., Chicago, Ill.

Portable Dead-Weight Tester

The accompanying illustrations represent a new portable device for testing pressure gages by dead weight. Differential pistons have been utilized to create a hydraulic multiplication, and friction between the parts has been minimized. The gage to be tested need not be removed from its working position after putting in the tee below the gage, Fig. 1. This instrument may be used with or without tubing and tripod to reach an elevated gage or as a bench machine without a tripod. The oil used to transmit pressure to the gage also serves to keep the working parts lubricated.

The design is based on the fact that the pressure

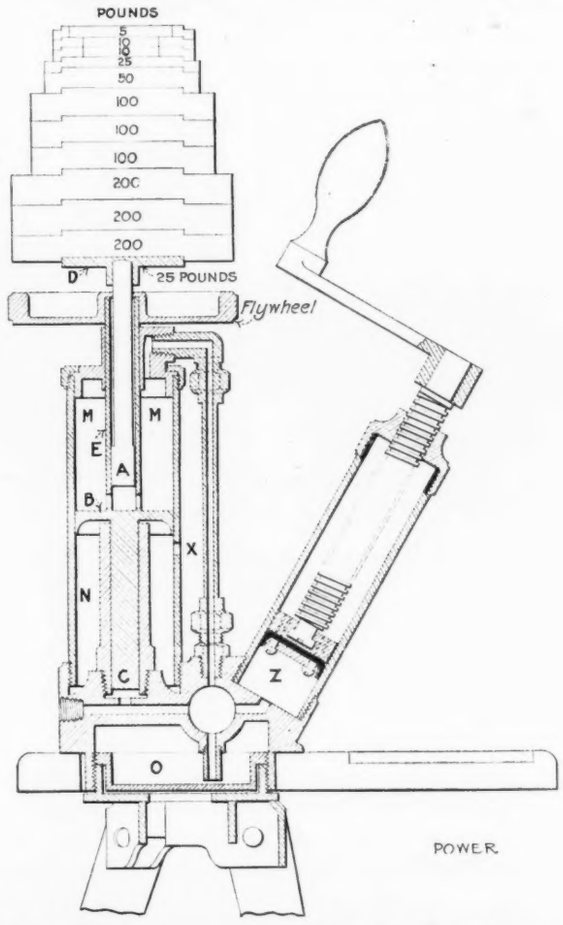


FIG. 2. SECTION THROUGH PORTABLE DEAD-WEIGHT TESTER

applied to the surface of a fluid is transmitted to every part of it. Referring to Fig. 2, the area B is an exact multiple of the area A. If the area B, for example, is 20 times that of A, and a one-pound weight is placed on the tray of the piston D, its pressure is transmitted undi-

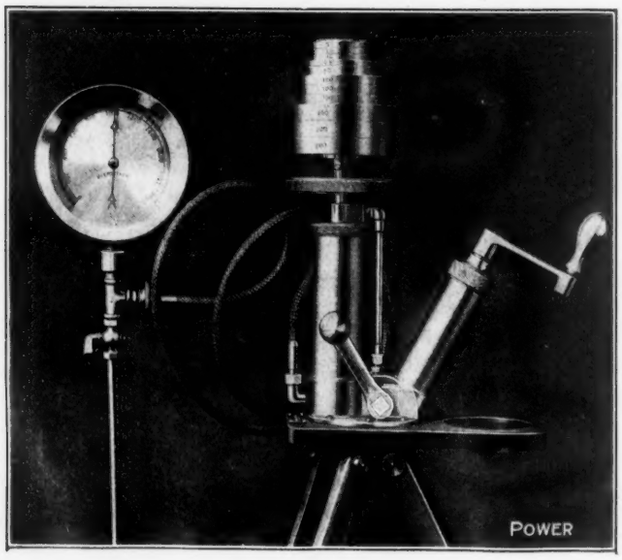


FIG. 1. TESTER CONNECTED TO GAGE

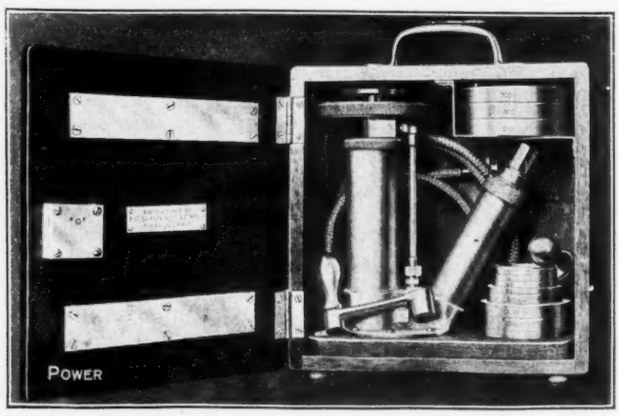


FIG. 3. TESTER IN CASE

minished to each surface unit of area B. In other words, the area B is exerting a pressure of 20 lb. on the area C. For example, let the area C be $\frac{1}{5}$ sq.in. Hence the weight registered by the gage is $20 \times 1 \times 5$ or 100 lb. per sq.in. In the same way the proportions of the plungers have been worked out to read pressure in kilograms per square centimeter. Decreasing either or both of the areas A and C, B remaining constant (for manufacturing purposes), the gage reading increases. If A and C increase, the pressure under C decreases.

As the weight employed is multiplied from 1 to 500 times, according to the capacity of the machine, so likewise the retarding effect of the friction would be multiplied. This serious obstacle has been overcome by the attachment of the flywheel to the piston E. The inertia of the floating weights allows the piston E to rotate around the piston D free from the effect of friction. The flywheel, carrying with it the piston E, eliminates the effect of friction within the cylinder, thus allowing the weights employed to give their true multiplied weight. The weight of the pistons is regulated in different instruments to give a reading of an even five on the gage for convenience. This is known as the initial constant and in high-capacity instruments is 25 lb. Therefore, when the weights, 1000 lb., are placed on the tray, the gage, if correct, should read 1025 lb. If it fails to register according to the weights used plus the initial, the error is at once evident. The constant value of a dead-weight test makes it the only true test.

This instrument is initially filled by immersing the tube in a vessel of oil and unscrewing the handle shown at the left of Fig. 2. This fills the oil cylinder Z, after which it is conveyed to the gage when attached and below the areas A and C. The direction of flow is controlled by the three-way cock, the handle of which stands at the front of Fig. 1. When the test has been made, the oil is stored for the next test in the reservoirs N and O, which are connected by a duct, and to the reservoir M, if desired. Air compression below the area B is eliminated by the hole X.

This equipment may be packed in a case, Fig. 3, its weight being but 17 lb. for tests from 1000 to 5000 lb. and as low as 13 for tests to 500 lb. Heretofore, 200 lb. dead weight has been necessary on the ordinary $\frac{1}{5}$-sq.in. tester to make a test to only 1000 lb.

This instrument was invented by Richard C. Cox, Cambridge, Mass., and is manufactured by the Simplex Tester Co., Brattle Building, Harvard Square, Cambridge, Mass.

Difficulties in Transportation

From the accompanying illustrations a good idea may be had of some of the transportation difficulties encountered in Australia. Figs. 1 and 2 show a heavy boiler being drawn over a sandy country road in Victoria, Australia, on the way to a mining plant. The boiler weighs slightly over 18 tons, and is being hauled by a bullock team.

FIG. 1. A SANDY ROAD

FIG. 2. A HARD HAUL

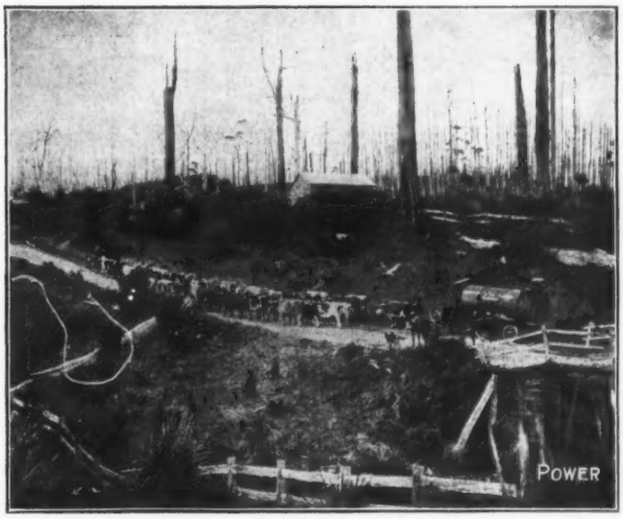


FIG. 3. SAFELY OVER THE BRIDGE

One peculiarity is that the wagon has six wheels. The extra wheels were necessary to carry the heavy weight, this vehicle at ordinary times being used for handling timber. Fig. 1 shows the team at work, and Fig. 2 is a view of the boiler being hauled up a small sand hill.

The photographs give a good idea of the tin-producing country in Australia, where the trees have been ringed and left standing dead, a ring of bark being removed near the base to kill the tree.

Fig. 3 shows a large surface condenser which has safely crossed a crudely constructed bridge.

Animal and Vegetable Oils; Their Preparation and Uses*

By R. C. Griffin

SYNOPSIS—The most valuable vegetable oils include linseed, china wood, cottonseed and olive oils. The fish oils are menhaden, seal, whale and sperm oils. The animal oils are neatsfoot, lard and tallow. Nearly all were formerly used for lubricating purposes, but now have mostly given way to mineral oils. The processes of obtaining these oils and the methods of detecting adulterations are described.

Animal and vegetable oils are often called "fixed oils," because in contradistinction to mineral oils they cannot be volatilized or distilled without decomposition. Chemically speaking, they are all glycerides of fatty acids. The gylcerides are neutral substances, whereas the fatty acids are, as the name implies, of an acid nature. A simple differentiation for the layman between neutral oils and fatty acids is this: When treated with caustic alkalies they both form soaps and a secondary product; but in the case of the glycerides this secondary product is glycerin, whereas in the case of fatty acids it is simply water. All acids, whether of a fatty or of a mineral nature, such as muriatic acid, when neutralized with caustic alkali, form water as a secondary product. All glycerides when so neutralized form glycerin.

The animal oils are obtained by merely heating the fatty tissues of the carcass; that is, by "rendering" or "trying out" the fat, or by boiling out the fatty oil with water. Vegetable oils occur mostly in the seeds or fruit of plants and are obtained either by pressing or by extracting with solvents. Since each of the oil-yielding plants and animals produces its characteristic oil, there are very many varieties of fixed oils. Animal oils are, as a rule, either nearly colorless or yellow; vegetable oils occur in various shades of yellow and green. Each variety generally has a distinctive odor. Their specific gravities (weight in comparison with an equal volume of water) vary from about 0.880 to 0.970 (water = 1.000).

Sperm oil is the lightest and the most fluid and castor oil the heaviest and the most viscous of the fixed oils. Certain of the vegetable oils, when exposed to the air, rapidly absorb considerable oxygen, forming thin, elastic, varnish-like films. Such oils are called drying oils, of which the best known is linseed oil, largely used in paints. Other vegetable oils show no tendency to form such films and these are called nondrying oils. There is also a third class of oils, called semidrying, which falls between the drying and the nondrying classes. For lubrication, either nondrying or semidrying oils must be used, such as olive, rape and castor oils. It is important, moreover, that all oils used for lubrication should be as free as possible from fatty acids. All fixed oils contain a certain amount of fatty acids, some more than others; and if the oil is allowed to stand in the air the amount increases and becomes "rancid." No oil which contains more than 4 or 5 per cent. of fatty acid should be used to lubricate any kind of machinery (we do not include here cutting oils). For delicate and intricate machinery the amount permissible is considerably less. The fatty acids not only attack and corrode metal, especially if it is brass, but at the same time form soaps which dissolve in the oil and cause it to get thick and gummy.

The animal oils most valuable for lubrication are lard, neatsfoot, tallow, whale, sperm and porpoise oils. Formerly these oils were widely used for lubricating purposes, but now they have given way to mineral oils. They still have other important uses, however.

Linseed Oil

Linseed is perhaps the most widely known of the drying oils. This class cannot be used as lubricants. The chief interest in linseed oil is its use in paints. It is obtained from the seeds of the flax plant and considerable quantities are produced in this country. The seeds are generally crushed between rollers and then heated in a mixing kettle and finally pressed while still warm.

Linseed, like all expensive oils, is often adulterated with cheaper oils, but it is difficult to detect such adulterations except by chemical analysis. Fish oils are known by the odor of the cold oil. Linseed oil itself when heated has a fishy odor. A good oil for paints should be clear, have a pleasant, clean odor, and should not separate gelatinous matter when heated. A "raw oil" when flowed over a clean piece of glass and allowed to stand in a vertical position should dry hard and free from stickiness within 75 hr., and a "boiled oil" within 24 hr. Its specific gravity is about 0.93.

China-Wood Oil

This oil, also called Japanese-wood and tung oil, is obtained from the seeds of a tree native to China and Japan. These trees produce nuts having three seeds each, and the oil is obtained by cold pressing the seeds.

It has a rather pale-yellow color and a characteristic and somewhat unpleasant odor. The Chinese oil has a specific gravity of about 0.941 and the Japanese about 0.933. The only heavier fixed oil is castor oil. A characteristic property of the oil is its forming a jelly when heated to 250 deg. C., or even when kept at 180 for an hour or two. The oil will also become solid if long exposed to the light. Apparently, China-wood oil is not extensively adulterated.

Soja-Bean Oil

This oil, also known as soy-bean oil, Chinese-bean oil, and simply "bean oil," is obtained from the seeds of a plant which grows largely in Japan, Korea and China. The soja-bean industry is one of the staples of Manchuria and Japan. The oil is largely used there for edible purposes, but it has recently been finding use in this country as a paint and varnish oil in connection with linseed; it has about the same specific gravity as the latter, but its drying properties are considerably inferior. It belongs to the class of semidryng oils.

Cottonseed Oil

Cottonseed oil, as its name indicates, is obtained from the seeds of the various kinds of cotton plants, and is

*Abstract from the "American Machinist," Feb. 5, 1914.

produced in large quantities in this country. It is obtained from the seeds by pressing, and is suitable for edible purposes. There seems to be a prejudice against using it under its own name. Many people prefer to buy "table oil," "salad oil," "butter oil," or "sweet nut oil," and would be probably quite surprised to know that such names are generally merely aliases for cottonseed oil.

The specific gravity is 0.925 and can be raised by treatment to about 0.94. On account of its drying properties and its tendencies to gum, it cannot be recommended as a lubricant. Its chief legitimate uses are for edible purposes and for soap making.

Rape Oil

This oil is also known as colza oil and is obtained from rape seed; it is clear, pale yellow, having a characteristic odor. Its specific gravity is about 0.914, and its viscosity is higher than any other fixed oil except castor oil—that is, only one other fixed oil will flow more slowly at any given temperature. This oil is semidrying and, therefore, it is not suitable as a lubricant for certain classes of machinery; its chief use is for burning.

Rape oil is often adulterated with other oils, such as cottonseed, corn, linseed, fish and mineral oils. The presence of fish oil can sometimes be detected by the odor, especially if the oil is warmed, and mineral oil is often shown by the "bloom" or fluorescence which it imparts. The other oils can be detected only by chemical analysis.

Olive Oil

This oil, as its name indicates, is obtained from the fruit of the olive tree. The finest edible oils, which are often called "sweet oil," are obtained from hand-picked olives, which are carefully crushed in a mill without breaking the pits, The meat is separated from the pits and pressed in a hydraulic press. A second grade of oil is then obtained by pouring cold water over the pressed meats and again pressing. This pulp is once more removed from the press, mixed with hot water and pressed, yielding the bright colored oils which are used for technical purposes, burning oils, lubrication and soap making.

The specific gravity of the oil is about 0.915. It is a nondrying oil, and formerly found considerable use as a lubricant for light machinery. The better grades are now too expensive for this purpose, however, and the cheap grades generally contain so much fatty acid that they are likely to cause trouble by the formation of gummy deposits. The oil is not at present much used for lubrication, although it is still employed, mixed with mineral oil, on spindles and looms. Many adulterants are used in connection with olive oil, especially cottonseed oil.

Castor Oil

Castor oil is obtained from the seeds of the ricinus plant, which grows in great quantities in all tropical countries. There are many cultivated varieties and the seeds, known as castor beans, vary considerably in size and appearance. The United States, particularly certain of the Middle West states, grows many castor beans, but the greater amount produced, however, is from imported beans, most of which comes from East India. The oil is obtained from the beans either by pressing or by extracting with solvents. A noteworthy peculiarity is that it contains a poisonous alkaloid known as ricine. It requires care to get the oil out of the beans without getting any of the poisonous ricine with it. Only the purest and most carefully prepared castor oil can be used for medicinal purposes.

For obtaining the best quality (medicinal) oils the beans are first passed through specially made rollers which crack the outside husks, or shells, which are then removed by a blast of air. The inner kernels are then pressed cold and part of the oil is squeezed from them. Only the cold-pressed oil can be used for medicinal purposes, since the ricine does not pass into the oil.

The crude oil obtained is refined by steaming and then filtering. When properly refined the oil keeps well and is not likely to turn rancid. It is nearly colorless or pale greenish yellow, and the taste is mild at first, then harsh; being more marked in American oils. The oil has the highest specific gravity of all the fixed oils (generally about 0.965), and it is also most viscous of them all. It does not begin to congeal until about 0 deg. F. Castor oil is completely soluble in about three to five times its volume of grain alcohol at 60 deg. F. If castor oil when mixed with three to five times its volume of alcohol does not give a clear solution, it is probably adulterated.

Castor oil is nondrying, and is, therefore, suitable for use in lubrication; generally it is comparatively free from fatty acids. It is, however, too viscous for most lubricating purposes, and is mostly used in a mixture. For heavy and quick-running bearings where considerable heat and friction are developed, it has been used with some success. Castor oil is also used as a belt dressing or preservative.

Menhaden and Other Fish Oils

Real menhaden oil is an American product obtained from the menhadden, a fish a little larger than the herring. The term "menhaden oil," however, is rather elastic, and oils obtained from other species are often sold under that name. The fish are placed in large pans, where they are boiled with steam. This disintegrates the flesh, and, after standing some time, the oil rises to the top and is skimmed off.

The color of the oil varies widely, depending on the freshness of the fish from which it was extracted and upon the length of boiling. The specific gravity of the oil is about 0.93.

The process of obtaining oils from other fish is similar to the above.

The principal use of menhaden oil is in the leather industries. In the machine shop it finds an important use as a quenching and tempering oil.

Seal Oil

Seal oil comes from the blubber of seals. In the good old days the oil was tried out of the fat right on board the vessel. Later, however, the seals were brought to special rendering plants on shore.

At the present time seal oil is obtained in a manner similar to the process used for whale oil. The blubber is carefully separated from the flesh, cut into strips, chopped up fine, placed in large pans and boiled with steam. The specific gravity is about 0.925. The best qualities are largely used as burning oils.

It is also used to some extent as a lubricant for screw-cutting machines, either alone, or mixed with mineral oil. It is similar to whale oil, and the latter is often

adulterated with it. Both seal and whale oil are used in tempering steel.

Whale Oil ("Train Oil")

True whale oil comes from the Arctic or Greenland right whale, but the so called "whale oil" of commerce is obtained from the blubber of various species of whales. Its history is almost exactly that of seal oil. Much of the American oil, however, is still tried out on board the whaling vessels, which deliver the crude oil to the refineries on the coast. A large right whale of the Pacific, or a full grown bowhead whale will sometimes yield as much as 7800 gal. of oil. The small white whale, on the other hand, will only yield from 30 to 100 gal. The right whale oil is of better quality than the Southern whale oil, which in turn is better than that from the finback whale.

The best quality of oil is obtained as "first runnings" from the separated blubber in the trying-out process.

Whale oil is somewhat similar in its appearance and fishy odor to sperm oil, but can be easily distinguished from it by its specific gravity, which is above 0.92, whereas that of sperm oil generally varies between 0.86 and 0.88. Even the best qualities have marked drying properties and it can, therefore, be used as a lubricant only for rough work. It is considerably employed, however, for mixing with mineral oil both for lubricating and as a cutting oil.

Since whale oil is a cheap oil, the only adulterants generally employed are still cheaper oils, such as rosin, mineral, cheap fish and sometimes seal oils. The rosin, and mineral oils are easy to detect, but the fish oils are difficult of detection, and it is impossible to detect seal oil by chemical means.

Sperm Oil

True sperm oil is obtained from the blubber and the head of the great sperm whale. A single male sperm whale will yield on the average from 2300 to 2800 gal. of oil. Arctic sperm oil comes from the smaller bottlenose whale, which is mainly found in the Arctic Seas, and yields about 250 gal. per whale. The two oils, however, are very similar.

The process of obtaining the crude oil is similar to the old process of trying out whale oil. It is practically all done aboard ship.

The true sperm oil, refined, is pale yellow and the best grades have only a faint odor. Bottlenose oil is usually darker and has a rather unpleasant fishy odor. Both oils are much more fluid than most animal or vegetable oils. On the other hand, when heated, their fluidity does not increase as rapidly as in the case of other fixed oils. This property of retaining its viscosity, with rising temperature, makes sperm oil valuable as a lubricant for light machinery and spindles, but it cannot be used for heavy work. Another property is that it has little tendency to become gummy or rancid. Bottlenose oil, however, shows more of this tendency, and is, therefore, less valuable. It is hard to distinguish these two oils apart, since there has appeared on the market a pale-colored "deodorized" sperm oil. The specific gravity is low, being only about 0.88. This makes it difficult to adulterate it with other fixed oils without detection.

Neatsfoot Oil

In theory neatsfoot oil is obtained by boiling out the feet of cattle in water, but in practice the commercial oil may include that from the feet of horses, sheep, swine and other animals. Some dealers ease their consciences by calling such oils "foot oil." The oil is generally a by-product of packing and slaughtering houses. In preparing it, the feet (after washing free from blood and dirt) are scalded with boiling water for 10 to 15 min. to loosen the hoof, which is then pulled out. The rest is boiled out in water for 8 to 10 hr. The bulk of the oil is skimmed off from time to time, poured through a screen, separated as much as possible from the water, dried by steam pipes, and finally filtered.

If properly prepared from fresh material the amount of fatty acid in neatsfoot oil is generally less than ½ per cent., but the oil ordinarily met with contains sometimes as much as 25 to 30 per cent. The chief factors in determining the value of a given sample are color, odor, low freezing point, or "cold test," and freedom from fatty acids. It should not be used for lubricating purposes if it contains over 4 per cent. of fatty acids.

Neatsfoot is pale yellow, and rather thin, with a specific gravity of about 0.915. Its odor depends upon the care with which it has been prepared and is sometimes very rank. On standing it deposits light-colored "stearine" or fat, sometimes in considerable amounts. On account of its high cost the oil is frequently adulterated. For this purpose vegetable oils are largely used, such as rape and cottonseed oil. Fish, mineral and rosin oils are also used. The odor and appearance will sometimes indicate whether an oil is adulterated, but generally adulterants can be detected only by chemical tests.

By far the greatest use of neatsfoot oil is in the leather industries, and as a belt dressing, either alone or mixed with other materials. It is a valuable lubricating oil for clocks and delicate machinery. Its main use as a lubricant at present, however, is, like tallow and lard oils, for mixing with mineral oils. It is pretty expensive to use alone, but forms with mineral oil a valuable lubricant. For this purpose, care should be taken to use only those oils with as little fatty acid as possible.

Lard Oil

Lard oil is a secondary product from the manufacture of lard and may be looked upon as the liquid part of the latter. It is obtained by allowing lard to crystallize at a carefully regulated temperature, and then separating the liquid and solid portions by straining under pressure. Just as the quality of lard varies largely with its source and the condition of the hogs, so lard oil varies in quality according to the lard from which it is obtained. Somewhat lower grades are used for burning and as lubricating oils.

The amount of fatty acid present in different specimens also varies greatly. This may be looked upon as an indication of the freshness of the oil and also of the care with which it was prepared. An oil which is practically neutral will become rancid on standing, especially if exposed to the air. The specific gravity of lard oil is about 0.915. Its color varies from practically water white to dark brown, depending upon the grade. Because of its high price, lard oil is frequently adulterated with mineral and cheap vegetable oils, and also to some extent with fish and blubber oils. Any considerable amount of the latter can be generally detected by their fishy odor. There are so called "mineral lard oils" which are mixtures of mineral and lard oils. In such oils the odor

of mineral oil is generally quite pronounced and they are usually thinner than lard oil and the surface has a different color to the body of the oil, due to the peculiar behavior of mineral oils toward reflected light. Oil men speak of this peculiarity as "bloom."

Tallow and Tallow Oil

The term tallow is applied to the fat of certain ruminant animals. Beef tallow is obtained from cattle; mutton tallow from sheep and goats. The operation of melting out the fat from the enveloped tissues and membrane is generally carried out in large kettles by means of live steam. Tallow at from 60 to 80 deg. F. is a mixture of solid and fluid fats. If subjected to pressure the fluid portion can then be separated out and is known as tallow oil.

Beef and mutton tallow are quite similar in their general characteristics. For most commercial purposes "tallow" may be either one or a mixture of both. Its chief interest in the power plant, however, is as a lubricant grease. Formerly it was used alone, but now its main use is in mixed greases, although it is sometimes used unmixed for lubricating heavy engine bearings, such as in rolling mills. It should be white in color and when melted should be clear and free from more than a slight amount of suspended particles. It should also have a fresh, clean odor, and be as free as possible from fatty acids. In freshly rendered tallow the amount of fatty acids is seldom over ½ per cent., but in commercial samples it may be as much as 25 per cent., or even more. Such rancid tallows should not be used for lubrication, since the fatty acids will attack and corrode metal. The upper limit should be not over 4 per cent. Beef tallow is less likely to become rancid on standing than mutton tallow.

Tallow oil is the liquid part of tallow, just as lard oil is the liquid part of lard. It is made by melting tallow and keeping it warm for several hours. Much of the stearine crystallizes and is removed by hydraulic pressure in canvas bags. If tallow oil is properly prepared, the amount of fatty acid is low. This makes it especially valuable for making compounded cylinder oils from mineral-oil stock. Such mixtures seem to have a greater "oiliness" than mineral oil alone. It is a lubricating oil for shaftings and heavy bearings, either alone or mixed with mineral oil. Care should be taken that the tallow oil is fresh and as free as possible from fatty acids, especially when used in cylinder oils. It should have a clean, sweet odor, and be pale yellow, or nearly colorless and free from suspended matter. It is seldom adulterated. Its specific gravity ranges from 0.911 to 0.915, and it flashes at between 475 to 500 deg. F.

Rosin Oil

Rosin oil is the principal product of the destructive distillation of colophony (common rosin). When we heat water it vaporizes into steam, and if this steam is condensed we get water back again unchanged. That is a process of plain distillation. When, however, we heat rosin, we also get vapors; but if they are condensed, we do not find the product is rosin again, but entirely different substances, the chief of which is rosin oil. The distillation breaks up the rosin chemically and destroys its original nature, hence it is called "destructive distillation." The process is carried out in cast-iron stills, which hold charges of from three to five tons, and are heated from beneath by a direct flame. The rosin oil distills over at above 570 deg. F., and if the distillation is carried clear to dryness, the amount of oil may be as high as 85 per cent. The residue in the still is rosin pitch, or in case the distillation is carried to completion, it becomes coke.

Crude rosin oil is a brown, viscous liquid with a characteristic odor and a marked "bloom," usually of a bluish or violet tinge. When heated to about 300 deg. F. for three or four hours, it loses from 1 to 5 per cent. of its more volatile constituents and assumes a green fluorescence. This fluorescence can be destroyed by chemical means, and by a process of refining the color can be made a pale brownish yellow. The specific gravity of the commercial oils generally ranges from 0.96 to 0.99, but not infrequently they run as high as 1.01. This latter case is interesting because it means that an oil of this specific gravity is heavier than water and will sink when brought in contact with water. A common use of rosin oil is in the manufacture of belt dressings.

Rosin oil is not suitable for lubricating machinery, but is often used in adulterating mineral and other lubricating oils. It can often be detected in such cases by its odor, which is almost unmistakable to one familiar with it.

Automatic Sampling of Coal

By L. C. Bosler

A great deal has been written and many discussions have taken place regarding the proper methods to em-

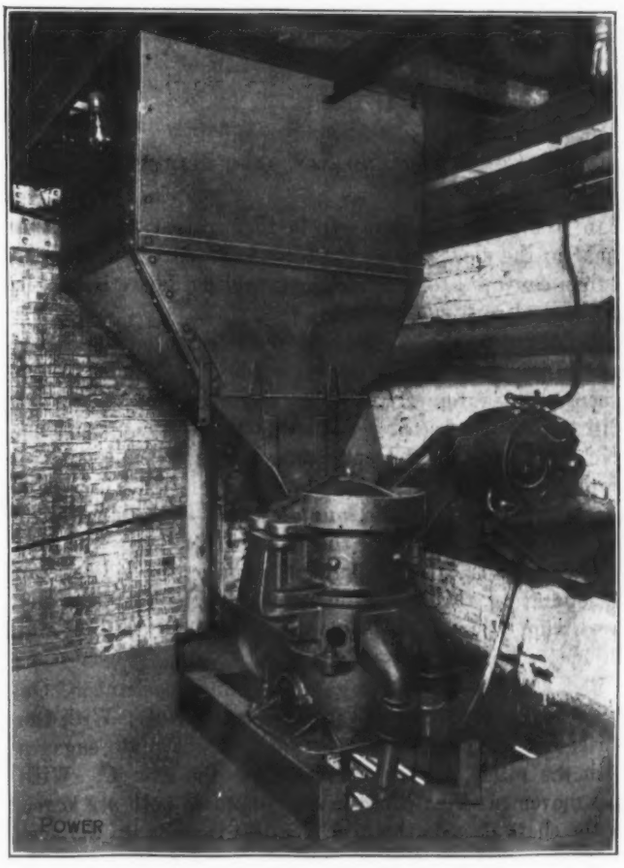


Fig. 1. Automatic Coal Sampler under Coal Conveyor

ploy to correctly sample coal. It seems strange to the writer that some of the larger consumers of coal should continue to use the ancient and crude system of sampling coal by taking a handful or shovelful from each car or bucket unloaded, as the case may be. For a proper analysis of a quantity of coal the first and important thing to get is a representative sample, after which this can be reduced to a working quantity by an automatic machine.

The Philadelphia Rapid Transit Co., has perfected and put in its Beach power station an automatic coal-sampling device by which all of the coal received is sampled without the human element entering into the operation at all.

Coal is received in boats and is unloaded therefrom by two electrically driven locomotive cranes on the pier. The coal is dumped into cars where it is weighed and is then delivered to a conveyor and carried to the crusher. The coal at this point is reduced to a size not greater

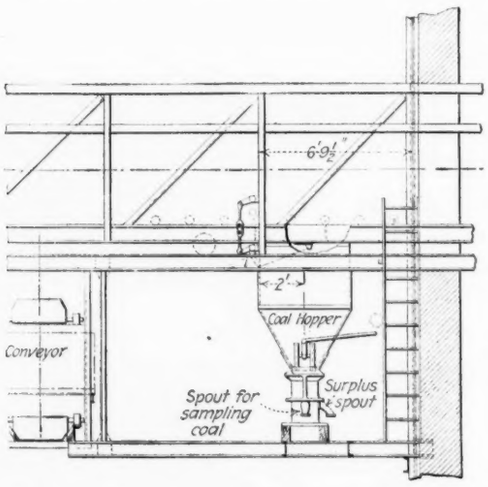


FIG. 2. CONVEYING AND SAMPLING MACHINE

than 3 in. in diameter. It is then raised to a height equal to the elevation of the top of the coal bunkers and is then conveyed to them. The sampling device is in this last named conveyor.

Referring to Fig. 2, the hopper for catching the major sample is underneath. Beneath this is a No. 00 rotary crusher and automatic sampler, made by the Sturtevant Mill Co., which receives the coal from the hopper. This machine performs two separate and distinct functions; it first grinds the major sample to any desired size and then divides it into two parts, one of which is the final sample, it being drawn from the front spout, while the balance falls back into the bunker through the side spout. By operating the adjusting wheel on the grinder, any proportion desired can be obtained between the final and the major sample.

Fig. 3 is a view of the gate-operating mechanism. On a flight of the conveyor is fastened a plate *A*. With the movement of the conveyor to the left this plate engages with the roller *B* and thereby raises the arm *C*. With this movement the arm *D* is also raised as both are keyed to the shaft *E*. As the arm *D* raises it pulls up the arm *F*, which, through the shaft *G*, is keyed to the arm *H*. At the end of this arm is fastened the rod *J*, which operates the gate. This gate is closed by the use of a counter-weight attached to the arm *F*. By the pull rod *K*, and yoke lever *L*, the arm *C* can be slid on the shaft *E* out of the path of the plate *A*, thereby cutting the apparatus out of service.

It will be seen that there must be a fixed relation between the position of the flight and the opening of the gate. With the gate wide open when the flight reaches the near side of the hole, the maximum discharge will take place as the coal is always banked against the flight.

The amount of coal desired in the major sample is governed by the number of openings of the gate per revolution of the conveyor and this in turn by the number of arms *A* that are fastened to the flights.

As an example, from each boat load, averaging 800 tons, a major sample of about 1500 lb. is taken. After passing the grinder and sampling machine the final sample is 6 lb.

In Fig. 1 the actual apparatus is shown under the coal conveyor in the boiler room. The two spouts re-

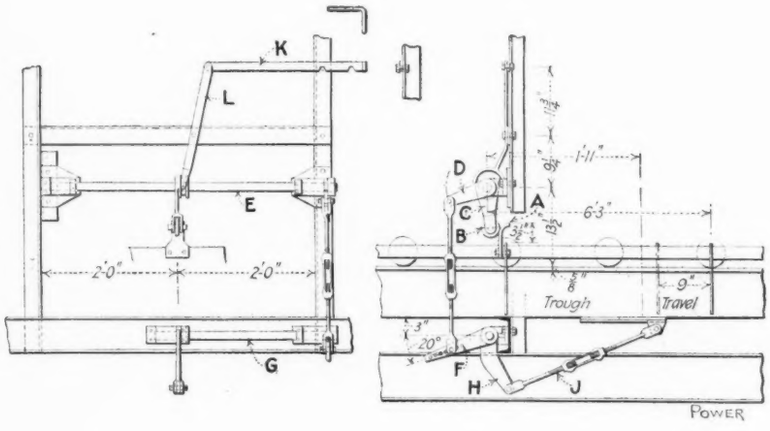


FIG. 3. GATE-OPERATING MECHANISM

ferred to in the foregoing are seen near the bottom of the grinder.

During the recent special tests made by the company on six samples of 1000 tons each, three major samples of 1500 lb. were desired from each cargo. To accomplish this, it was necessary to have four gate openings per revolution of the conveyor, this delivering the required amount. The opening in the bottom of the conveyor trough through which the coal passes to the hopper is 4x6 in. and by actual experiment was found to deliver 3 lb. of coal per opening under ordinary conditions of moisture.

All of the apparatus except the crusher was designed and erected by the company's engineers and has been in continuous service for a year, giving excellent results.

Discharge From Traps—Steam traps should not discharge along the foundation walls of the boiler house or of any other building. The continued discharge from these traps will in time effect the settlement of the building's walls Where the condensation is needed as make-up water it should be discharged to the feed-water heater or direct to the boiler by any of the approved methods. The drips from exhaust heads are often allowed to drain directly on the roof of the boiler house, and thence to the sewer by way of a rain-water conductor. This is bad practice, as the hot water will damage any roof of modern construction, such as a roof of tar and gravel composition.

Electrical Kinks for the Operating Man

By H. Winfield Secor

The operating engineer is often required to make a few rough tests on electrical machinery about the plant, and particularly on motor and dynamo armatures. It is well to know a few simple testing schemes, so that armatures can be tested without any elaborate apparatus, and a few methods which have been extensively adopted in practice are mentioned here.

In Fig. 1 is indicated a common shop method of testing out direct-current armatures of the lap- or wave-wound types. Current is passed through the armature by way of the brushes or, if the armature is not in place, at points corresponding to the usual brush positions on the commutator, which can be effected by tying the two test leads T and T_1 on the commutator by means of a piece of string. A milli-voltmeter, or ammeter without a

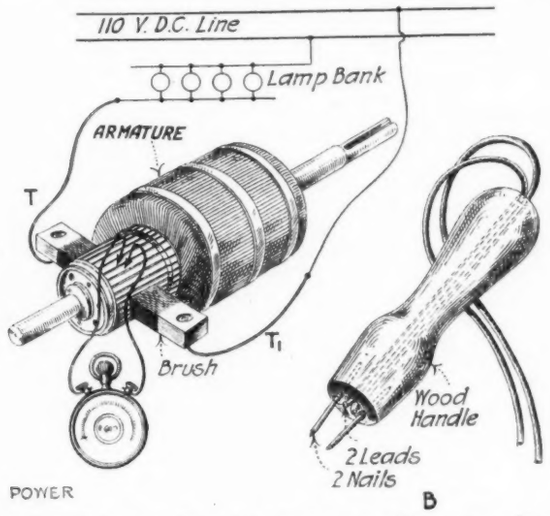


Fig. 1. Testing Out Armatures by Means of Direct Current

shunt, is connected across two adjacent commutator bars as shown. A simple testing handle fitted with two nail prongs, as at B, Fig. 1, is handy in making such a test, and a bank of several 110-volt lamps (or 220-volt lamps on a 220-volt circuit) is used for limiting the current passed through the armature under test.

The current through the armature should be regulated until a suitable arbitrary reading is had on the milli-voltmeter, and the readings across any two adjacent bars will be approximately the same, if the armature is in proper condition. After making a test across the various pairs of segments between the leads T and T_1, these should be shifted, keeping them the same distance apart and repeating the bar to bar test until the whole commutator has been tested. This is the usual shop test on armatures newly wound, or where the winding or commutator connections have been repaired. If a higher meter deflection than usual is observed, a loose or wrong connection of the armature coils may be looked for. If the meter needle goes off the scale there is probably an open coil in the winding at the point under immediate test. Where a reading lower than normal occurs, a short-circuit, perhaps in the turns of the coil but frequently between the commutator bars, where the leads have been soldered to it, will be found. It is usual to test the insulation resistance of the armature winding from the steel shaft and core by connecting the milli-voltmeter between one testing lead, say T_1, and the shaft, while the

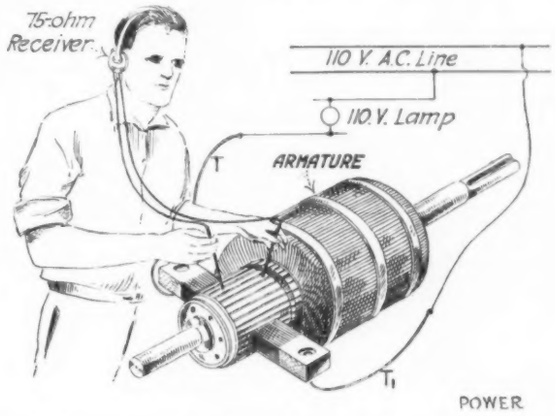


Fig. 2. Testing Out Armatures by Means of Alternating Current

other testing lead T is left connected to the commutator. Practically no deflection should be observed.

In Fig. 2 is shown a test similar to that just described, except that an alternating-current circuit is utilized. A 110-volt lamp is connected in series with the test circuit, but instead of using a voltmeter for the bar to bar test, a common telephone receiver is employed. After the strength of the hum has been noted for several coils, trouble can soon be located. A decreased hum indicates a partial or completely short-circuited coil, and the commutator

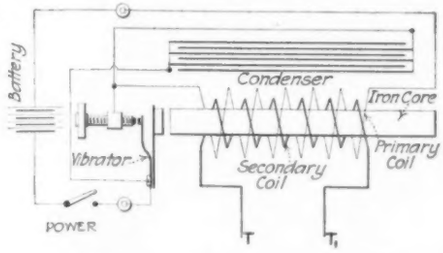


Fig. 3. Induction Coil

connections should be carefully examined. Sometimes where a coil lead passes over the turns of a neighboring coil, the insulation will be found to have chafed away, causing a short-circuit. Again it may be in the coil itself, and then, of course, the coil will have to be removed. An extremely loud hum in the receiver indicates an open circuit in the coil connected to the bars under test. With a little practice one can quite accurately diagnose armature trouble by this method. Resistance may be inserted in series with the receiver if the hum is too high and the lamp used should be of the same voltage as that of the testing circuit.

A substitute for the alternating-current circuit, which is not always available, is a small induction coil connected as in Fig. 3. A small tinfoil and paper condenser can be shunted across the vibrator to intensify the secondary current if desired, but if the coil is fairly strong, this will not be necessary. The secondary leads T and T_1 are connected to the commutator and used with a receiver, as in Fig. 2.

A simpler source of interrupted current is a common battery buzzer, with test leads connected across the vibrator.

A useful armature stand, two of which are required to support an armature, is shown, Fig. 4. It consists of a piece of 2 to 2½-in. iron pipe, threaded into a cast-iron flanged base having a spread of preferably about 16 to 18 in. At the top it is surmounted by a pipe flange, and a casting carrying two rollers. The latter permit of easily turning even heavy armatures, and it is convenient for overhauling and balancing them. This stand may be arranged so that the armature-bearing rollers may be raised and lowered to any desired height.

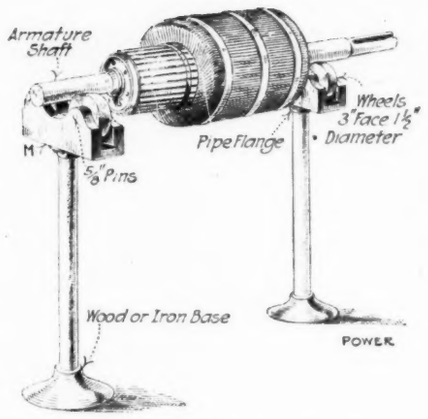


FIG. 4. ARMATURE STAND

Cutting Down the Fuel Bill

BY R. M. CHARGERS

SYNOPSIS—Saving 35 per cent. of the coal bill in a direct-current railway plant, averaging 150,000 kw.-hr. per month.

In this article will be given in part the details of the operation pursued by an efficiency engineer in reducing the coal bill of a certain power plant. In this case the reduction was 35 per cent. in the cost of coal for making direct current to supply an interurban railway.

The boiler-room equipment consists of five 350-hp. water-tube boilers equipped with hand-fired stationary grates. Natural draft is furnished by two steel stacks. The coal is Georges Creek run-of-mine, one of the best grades of bituminous coal in the country, running about 14,500 B.t.u. per lb. Practically all attempts to increase efficiency were confined to the boiler room.

The plant had for years nominally operated four boilers, burned on an average about 675 tons of coal per month and turned out about 150,000 kw.-hr. in the same period. The boilers were banked from 1 to 5 a.m. The total steam per kilowatt-hour averaged close to 54 lb.

Upon being called to the property the conditions existing were not unlike those in other plants with which the writer has had to deal. The average draft over the fire was 0.5 in.; the average CO_2 content in the gases was 7.5 per cent. in the first pass and 4 per cent. in the last; the intervals between firing periods were from 40 to 50 min.; the fuel bed was carried about 18 in. thick in front of the fire doors and from 5 to 10 in. on the rear of the grates; the dampers could be operated rather crudely from the rear of the boilers; the settings were leaky, especially around the doors and drums.

The operating force never had any instruments for testing at its disposal, or been instructed along the lines of efficient boiler-room operation. It was necessary to show that these conditions were not good practice and that considerable coal could be saved by slightly changing them. Of course, the usual protests were made, such as the varying load conditions, the inefficiency of the engines, poor coal, lack of help, etc.

It was finally made clear that 4 per cent. CO_2 indicated poor furnace operation, and that 0.5-in. draft was much too high for burning 7 lb. of coal per square foot of grate surface per hour. The firemen were also shown that, contrary to their former opinion, no mystery surrounded CO_2 and the theory of draft, and that it was unnecessary to understand the laws of Boyle, Charles, Gay-Lussac and Avogadro to put them into common, every-day boiler-room practice.

After interest, enthusiasm and coöperation had been aroused, the work of building up the boiler and furnace efficiency was started. All the coal was weighed, the water measured, and the steam metered—in fact, accurate data were kept on the entire plant. During the first 24 hours the firing intervals were reduced to about 30 minutes, the fires kept more even and thinner, the draft cut down to an average of 0.36 in. over the fire, the water level kept more constant, and the CO_2 in the last release averaged 7 per cent. As a result, the evaporation increased from an average of 6.75 to 7.5 lb. of water per pound of coal, bringing the boiler and furnace efficiency up to 50 per cent.

On the following day the dusting doors were made to close tightly and many of the air leaks were stopped around the drums and headers. The CO_2 ran 7.5 per cent. in the last pass and 10 per cent. in the first, showing that there was yet considerable air leakage. The intervals between firing were then cut to about 22 min., the fires kept more even and thinner, and the draft throttled down to an average of 0.20 in. over the fire. This 24-hour period showed an increase in evaporation over the previous one and the boiler and furnace efficiency was brought up to 57 per cent.

To get still better results, it was explained to the force that one boiler would have to be cut off the line to give more nearly rating on them and a slight overload during the peaks. (We had been informed that three boilers would not pull the load, especially the peak.) One boiler was taken off, however, and the peak carried with no

reduction in the steam pressure; the draft being regulated to take care of the extra demand on the boilers.

To be brief, the results of the next four days increased in like proportion to those of the first two days. In the meantime, still another boiler was cut off, leaving only two fired up. On the seventh day the firing was done about every 12 to 14 min. On account of other duties, the firemen could not further reduce this interval. More air leaks were stopped and the CO_2 maintained at 10 per cent. in the last release. The draft was now about 0.14 in., the fires approximately 10 in. thick and the bare spots scarce. The results then were: Evaporation, 10.4 lb. per pound of coal; coal per kilowatt-hour, 5.4 lb.; efficiency, 69.5 per cent.; this is a reduction on coal costs alone of 40 per cent.

Since this work of several months ago, the reduction in fuel has averaged 35 per cent. With coal at $3 per ton, this means a saving in this plant of over $700 per month.

Heat-Engine Efficiency Chart

By Henry L. Thomson

The determination of thermal efficiency is usually based on the fuel consumption per brake horsepower-hour. As specific gravity and liquid measure often enter into the problem, calculation of the efficiency becomes a tedious process. However, these calculations can be readily solved by a logarithmic chart, from which the thermal efficiency can be determined from the fuel consumption, whether given in pints or pounds of fuel of any specific gravity per brake horsepower-hour or in cubic feet of gas per brake horsepower-hour.

These various classes of fuels cover the field of the sources of energy for heat engines, and include gasoline, oil, gas and producer-gas engines, steam engines of all types, and even the hot-air engine.

This chart will be found particularly convenient in running tests with gasoline and oil engines, with which the fuel consumption is measured in pints per brake horsepower-hour, while in the Diesel and often in the semi-Diesel type, it is measured in pounds per brake horsepower-hour.

It is always necessary in finding the thermal efficiency to know the number of British thermal units in the fuel used. This is particularly true in the case of the hot-bulb type of oil engine, which burns such a variety of fuels, with such a range in specific gravity and calorific value.

AVERAGE HEAT VALUES FOR A NUMBER OF FUELS

Fuel	Specific Gravity	B.t.u. per Lb.	B.t.u. per Cu. Ft.
Gasoline	0.65-0.72	18,000	....
Naphtha	0.74	18,000	....
Kerosene	0.78-0.82	20,000 to 22,000	....
Distillate	0.80-0.90	17,000 to 20,000	....
Alcohol	0.79	12,000	....
Penn. crude oil	0.92	21,000	....
Oil gas	...	.....	1,000
Coal gas	...	.....	650
Water gas	...	.....	630
Producer gas	...	.....	110 to 150
Blast furnace gas	...	.....	100
Natural gas	...	.....	1,000
Bituminous coal	...	14,000	....
Anthracite coal	...	13,500	....
Coke	...	13,500	....

As an example in the use of the chart, find the thermal efficiency of a hot-bulb engine which burns 0.7 pint of distillate per brake horsepower-hour (0.85 specific gravity, and B.t.u. 20,000). Move to the right up the diagonal line of 0.7 pint to the horizontal line of 0.85 specific gravity, then on the diagonal to the left to 0.61 pound; then to the right on the diagonal to the horizontal B.t.u. line of 20,000, and on the diagonal to the left to 20.9 per cent. thermal efficiency.

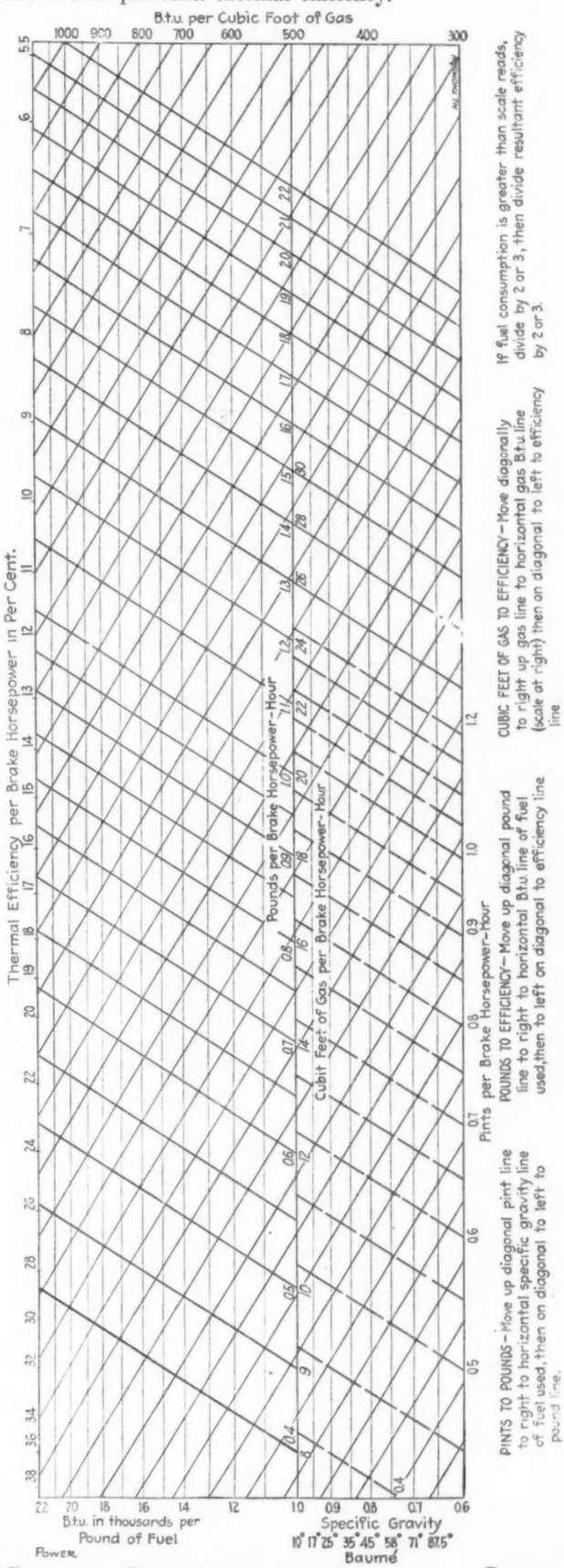

B.t.u. per Cubic Foot of Gas
1000 900 800 700 600 500 400 300
Thermal Efficiency per Brake Horsepower in Per Cent.
Pounds per Brake Horsepower-Hour
Cubit Feet of Gas per Brake Horsepower-Hour
Pints per Brake Horsepower-Hour
If fuel consumption is greater than scale reads, divide by 2 or 3, then divide resultant efficiency by 2 or 3.
CUBIC FEET OF GAS TO EFFICIENCY—Move diagonally to right up gas line to horizontal gas B.t.u. line (scale at right) then on diagonal to left to efficiency line
POUNDS TO EFFICIENCY—Move up diagonal pound line to right to horizontal B.t.u. line of fuel used, then to left on diagonal to efficiency line
PINTS TO POUNDS—Move up diagonal pint line to right to horizontal specific gravity line of fuel used, then on diagonal to left to pound line.
B.t.u. in thousands per Pound of Fuel
Specific Gravity
10° 17°25° 35°45° 58° 71° 87.5°
Baumé
POWER.

Chart for Determining Efficiencies with Different Fuels

100,000,000-Gallon Centrifugal Pump for Pittsburgh*

By Geo. H. Gibson

SYNOPSIS—Describes the 100,000,000-gal. turbine-driven De Laval centrifugal pump for the Ross pumping station, Pittsburgh, Penn. The performance data of the pump are given.

About two years ago the water department of Pittsburgh asked for bids on a pump to be installed at the Ross pumping station to handle 100,000,000 gal. per day against a total head of 56 ft., including 18 ft. suction lift, pumping from the Allegheny River into the Aspinwall filtration plant. The pumping engines previously installed were reciprocating engines driving centrifugal pumps. However, the possibility of securing turbine-driven centrifugal pumps suggested to the engineers a careful canvas of the situation, the more so as the recent introduction of reducing gears of large capacity had for the first time made possible the combination of high-efficiency turbines with standard-speed pumps.

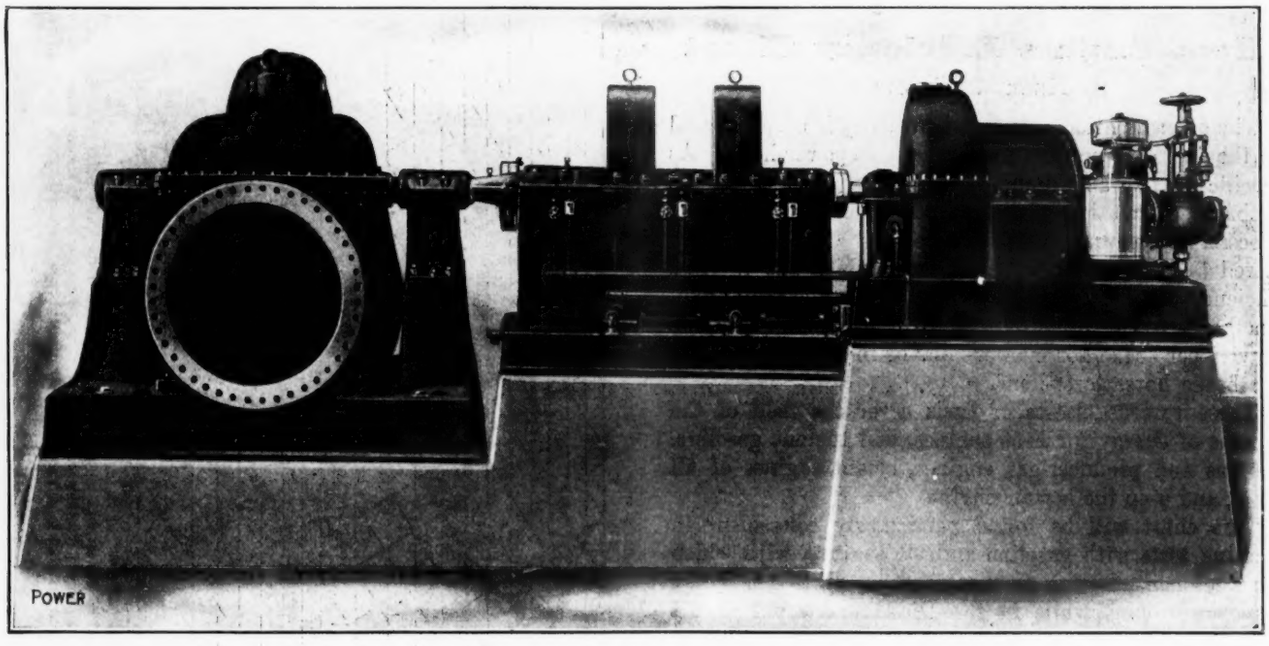


Fig. 1. The 100,000,000-Gal. Pump for Ross Pumping Station, Pittsburgh

The apparatus selected, Fig. 1, is a pressure-stage turbine driving a single-stage centrifugal pump by means of a double helical speed-reducing gear, all built by the De Laval Steam Turbine Co., of Trenton, N. J., and guaranteed to give a duty, including all steam and power used by auxiliaries, of 115,000,000 ft.-lb. per 1000 lb. of dry steam at 150 lb. pressure gage.

A ten-hour acceptance test for duty and capacity was made and readings taken every ten minutes. The steam pressure was measured above and below the governor valve by gages which were calibrated after the test, while moisture was measured by a throttling calorimeter attached immediately above the throttle valve. Vacuum measurements were made at the turbine exhaust by mercury column, and barometer readings were obtained every hour from the U. S. Weather Bureau. The condensate from the surface condenser, which included also the exhaust from the dry-air pump, was weighed in two tanks on calibrated platform scales. The discharge pressure of the pump was measured by means of a spring gage attached to the discharge pipe, close to the discharge flange of the pump. The gage was calibrated by means of a dead-weight tester. The suction lift was measured by a mercury column attached close to the suction flange of the pump, 5½ ft. below the center line. The pump as installed in the station is shown in Fig. 2.

The capacity was determined by a venturi meter of 48-in. throat diameter, the flow being indicated by a mercury manometer, the scale of which was graduated in million gallons per day. Shortly before the official test, the venturi meter was calibrated by a volumetric test of one hour's duration. While the pump was discharging into the receiving basin at the filtration bed, the elevation of the water in this basin was taken every five minutes, both by a hook gage and a Y-level, the total rise in the basin during the one hour's run being 4.55 ft. This showed that the scale furnished with the venturi manometer was slightly lower than the actual capacity obtained in the volumetric test, the average reading of the scale during one hour's run being 97,250,000 gal. per day, and the actual capacity from the rise in the basin being 98,170,787 gal. As 100,000,000 gal. per day on the scale corresponds to a reading of 2¼ in. of mercury, the coefficient of the venturi tube is 0.967, while the volumetric test gives 0.976, which would seem more likely for a venturi tube of this size.

*For an analysis of the advantages of turbine-driven centrifugal pumps, see Mr. Gibson's article in the Oct. 6 issue, page 489.

The following is a summary of the principal data:

Steam pressure at throttle	151.07 lb.
Nozzle pressure	145.3 lb.
Vacuum	27.87 in.
Vaccum (corrected)	28.38 in.
Speed	344.7 r.p.m.
Capacity from venturi meter	101,650,794 gal. per 24 hr.
Capacity (corrected)	102,610,000 gal. per 24 hr.
Capacity, gal. per minute	71,260
Total head	58.713 ft.
Water hp.	1056.9
Total steam (for 10 hr. 15 min.)	179.442 lb.
Steam per hour	17,506 lb.
Duty	119,500,000 ft.-lb.
Steam per water horsepower	16.59 lb. per hr.
Electrical hp. consumed by circulating and hot well pump motors	16.26

The electrical input to the circulating pump and hotwell pump motors was measured by portable calibrated instruments. The impeller is shown in Fig. 3.

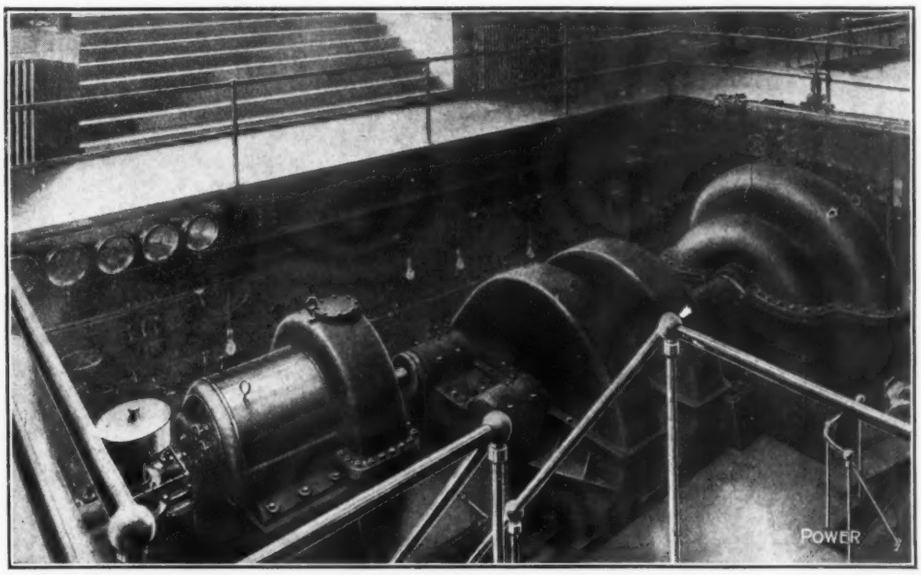


FIG. 2. VIEW OF PUMP IN THE STATION

According to the contract, the steam to be charged against the turbine for driving the auxiliaries, was to be the electrical horsepower consumed by the motors multiplied by the steam rate of the main turbine per water-horsepower, although in stating the duty of the main unit, it would seem more reasonable to make the comparison on the basis of shaft-horsepower, since the auxiliaries might have been arranged to be driven by the main turbine, while the method specified penalizes the main turbine for the inefficiency of the pump and that of the motor. However, taking the conditions stated, 16.26 electrical horsepower, at 16.59 lb. of steam per water-horsepower-hour, amounts to 270 lb. per hr., so that the total steam consumption of the unit would be 17,776 lb. per hr., giving a duty, including auxiliaries of 117,700,000 ft.-lb. per 1000 lb. of steam. The quality of the steam, however, was only 0.977, so that the duty based on dry steam would be 122,300,000 ft.-lb. and the steam per water-horsepower, 16.2, making the additional consumption on acount of the circulating and hotwell pump motors, 263 lb. per hr., or a corrected duty of 120,500,000 ft.-lb. with dry steam, including all auxiliaries.

Due to the small size of the intake and to low water, a certain amount of air entered the suction pipe, probably reducing the capacity and also the duty, for while a test conducted at the builder's works and later readings at Ross pumping station taken under normal water conditions showed a delivery of 108,000,000 gal. when running at 345 r.p.m., the official test showed only 102,000,000 gal. at the same speed. That the excessive suction lift and the presence of air were detrimental was also evident by shocks in the suction line, which were not experienced when the pump was running with the normal suction lift.

The pump is of the double-suction type, with 48-in. inlet and outlet openings. The casing is split horizontally and both suction and discharge openings are in the bottom part, the suction opening connecting directly to a vertical suction pipe coming up between the bearing pedestals, which are independent of the pump casing proper. The casing cover can therefore be removed without disturbing the suction and discharge connections, giving immediate access to the impeller and to all other internal parts which may be lifted out after removing the bearings caps. The impeller is of bronze, and is mounted upon a steel shaft, protected by bronze sleeves which abut against the impeller. These serve to prevent corrosion by the water and to receive any wear due to the packings.

A centrifugal pump is most likely to wear at the points where the impeller runs close to the casing, separating the suction from the discharge chamber. The pressure forcing water back from the discharge to the suction at this point is the full head developed by the pump. Originally, centrifugal pumps were provided with smooth cylindrical or flat surfaces at this point, resulting in considerable leakage initially and greater leakage later on as the clearance increased by cutting by water or wear from particles of grit and other foreign matter. To repair this damage quickly and inexpensively remov-

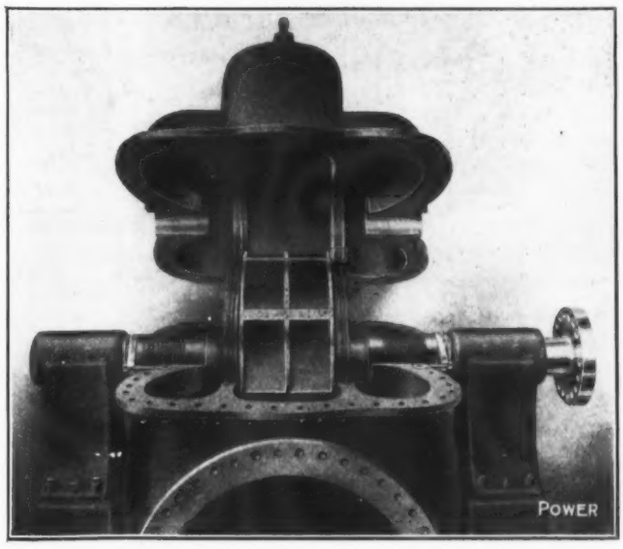


FIG. 3. SHOWING THE IMPELLER

able rings, Fig. 4, were attached to the casing and to the impeller. In the present pump, these rings are of a special type, having tongues and grooves which interlock with one another to form a labyrinth. One pair of rings is securely attached to the impeller while the other fits in recesses in the casing and may be lifted out with the impeller.

The complete pump measures 11 ft. lengthwise of the shaft and 10 ft. high. It is supported on a bedplate which is independent of the turbine and gear bedplate.

The space occupied by the turbine complete is 12½ ft. in length and 9½ ft. in height. The turbine shaft, running at 3600 r.p.m., is connected by a flexible coup-

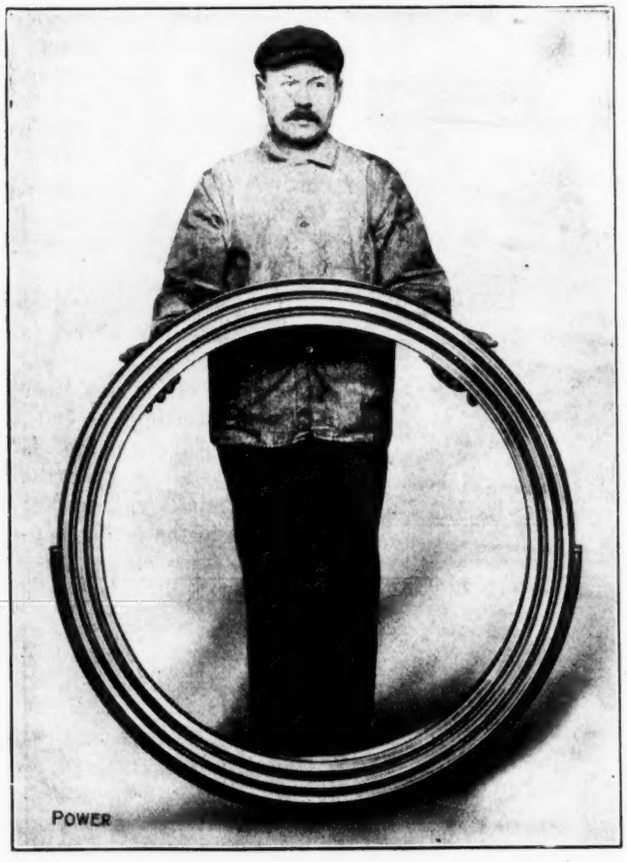


FIG. 4. STATIONARY LABYRINTH WEARING RINGS

ling to the pinion of the double helical reducing gear, which in turn drives the pump at a speed of 350 r.p.m. The teeth are of the involute type, and are inclined at an angle of 45 deg. to the line of contact, so that 20 teeth are in contact in each pinion at one time.

The bearings of both pinion and gear rest in seats scraped to dimensions in a rigid cast-iron gear casing, by which they are held permanently at the center distance for which they were designed.

The condenser equipment differs from the usual in that instead of a so-called "water works" condenser in the suction line, one of standard type served by an independent circulating pump is employed. To have placed the condenser in a suction line passing water at the rate of 100,000,000 gal. per day would have given rise to excessive friction, more than equivalent to the power required to drive the independent circulating pump. The Wheeler condenser contains 2360 sq.ft. of tube surface and is placed transversely to the axis of the pumping unit, immediately underneath the turbine, so that the condenser shell connects directly to the turbine exhaust outlet by an expansion piece with free exhaust outlet connection. The circulating pump is a De Laval horizontal single-stage centrifugal pump, driven by a variable-speed motor, and is designed to deliver 3000 gal. per min. against 12-ft. head when running at 710 r.p.m. The hotwell pump is a De Laval single-stage centrifugal pump with vertical shaft, motor-driven at 1800 r.p.m. The air pump is of the rotative dry-vacuum type, with a 5-in. steam cylinder, 12-in. air cylinder and 12-in. stroke.

[It may be of interest to note that the following cities have decided to install similar pumping units, though not so large, the capacities ranging from 6½ million to 30 million gallons: Philadelphia, Toronto, San Antonio, Cleveland, Omaha and Lynn, Mass.—EDITOR.]

Standard Pipe Threads

The threads, as produced in the Briggs system, are shown in the illustration. The taper employed has an inclination of 1 in. to 32 to the axis, therefore the total taper is 1 in. to 16 in., i.e., ¾ in. to the foot or $\frac{1}{16}$ in. to 1 in. The angle of the thread is 60 deg. and its depth four-fifths of the pitch, or $0.8\frac{1}{n}$, where n equals the number of threads per inch.

Threads F are perfect at top and bottom. Back of these are two threads with perfect bottoms but flat tops; behind these are the imperfect ones produced by the chamfer of the die.

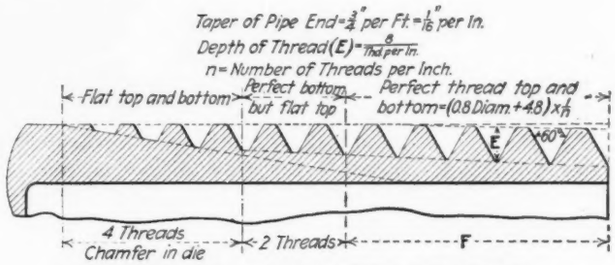
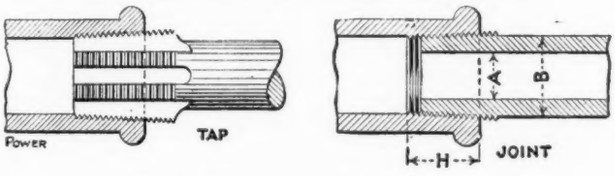


FIG. 1. LONGITUDINAL SECTION OF BRIGGS PIPE THREAD



BRIGGS' STANDARD PIPE THREAD

It can be readily seen by the foregoing how necessary it is to have the pipe and fitting sizes match, so that the full, perfect threads in each will register with the other. A thread made up more or less than this will result in a less perfect joint.

PIPE THREADS

Diameter	Threads per Inch	Diameter of Drill
⅛	27	21/64
¼	18	7/16
⅜	18	37/64
½	14	17/32
¾	14	11/16
1	11½	1 7/16
1¼	11½	1 15/16
1½	11½	1 23/32
2	11½	2 7/16
2½	8	2 11/16
3 to 10 inc.	8	

Editorials

Work with the Firemen

On page 642 of this issue appears a short article telling of a large saving made in a boiler room through the efforts of an efficiency engineer.

Results were obtained by the simple employment of common sense and by diplomatic instruction of the firemen in better firing methods. Nothing of a radical nature was done, and the same results could have been brought about by any engineer thoroughly alive to his work. Leaks in the setting were stopped, the draft was reduced to a proper intensity, the thickness of the fuel bed was lessened, coal was fired at shorter intervals and the number of boilers on the line was reduced. The firemen were shown how to read a draft gage and were told the proper intensity for the particular fuel burned and the thickness of fuel bed carried. The use of the Orsat and the relation of its readings to economical combustion were not only explained but the firemen were shown directly the results of their work. It soon became clear to them that a complete understanding of the laws of physics and chemistry was not necessary to obtain results. It was not a difficult matter to learn how to read a gage, and by watching the results of their work under the tutelage of a competent instructor, good firing methods were gradually approached and a knowledge gained of how to maintain them.

It seems to be the opinion of many that the average fireman is not susceptible to changing hard-and-fast methods of firing; that he has been doing this work in a certain way and no doubt thinks the results he is getting are the best obtainable. It is not an easy matter to swing any man from his rut; his ways of doing things become fixed and the longer they continue, the more difficult is the change.

Of course, results in the boiler room speak for themselves, but accurate records are necessary with which to draw a comparison. Close account must be kept of the water, coal, labor employed and the output, and, above all, the fireman must be shown how to produce good results. It is not enough to hand him a log of the plant all worked out for his special benefit. To gain his confidence it is necessary to work with him in the boiler room. Tell him the reason for every change made and by means of the draft gage and the Orsat, show him the direct results. Any man with a spark of intelligence will respond to such treatment. His interest will be aroused and when he starts to ask questions, the hardest work is finished.

Then is the time to bring out the log. Let him know the results he is getting from day to day and from month to month. Give him access to good power-plant books and periodicals, so that in his reading he may draw a comparison between other plants and his own. Give him a clean place in which to work, wash and dress, and pay him a suitable wage for handling the largest item in power costs. In other words, make the fireman a real cog in the wheel of power-plant operation, and see that each element is well greased to preserve uniformity and smoothness of operation.

A saving of thirty-five per cent. in the coal bill is not small. There would not be the same opportunity in all plants, but in the great majority some saving could be made. A little pioneer work with the firemen at the source of steam power will prove worth while. Try it out in your own plant and let us know the results.

Buying Power Machinery

Many buyers of power and other machinery do not know how to buy. They do not seem to know exactly what they want, which is often natural and permissible, but they should know what is to be expected of the new machinery, and that is what the manufacturer always wants to know.

For instance, an owner finds that he is burning too much coal. He wants to invest in apparatus that will net him returns. So, he writes to a manufacturer who claims to have the cure-all. He doesn't send any plant details, just a letter saying: "How much would it cost to install your apparatus? We have return-tubular boilers and a noncondensing Corliss engine. We now use ——— pounds of coal per year. How much would you apparatus save?"

The manufacturer replies with a general letter, stating what his apparatus has done for others, names his price, asks for pipe-connection details, sends a catalog or so, and rests his case.

The buyer sends the pipe details and asks for more information. He receives an immediate reply, consisting principally of sales arguments.

After an exchange of a few more letters, in which the manufacturer usually shows the upper hand because of his better knowledge of efficiency apparatus, the buyer succumbs and buys, and there the deal ends. Sometimes the sale is made even more quickly than this.

The manufacturer is not dishonest. The apparatus he sells doubtless improves economy, and the buyer may be perfectly satisfied, but that does not say he made the best investment. It is better than none at all, but he did not make the most of his opportunities, because he did not know how to go about it. His knowledge of modern machinery is hazy. He does not know what is best, so makes a blind stab at efficiency in general, using what he thinks is his best judgment.

The proper way to buy power and other machinery is to first write out all power-plant conditions in detail that would or might be affected by the new apparatus. The more the manufacturer knows about the plant the more accurate will be his figures and recommendations. A sketch or sketches should be made, preferably to scale, showing the present arrangement and giving the principal dimensions. Then, what the new machinery is to accomplish should be explained.

With this done it will be unnecessary for the manufacturer to write letter after letter. He will appreciate that "sales arguments" will not help him much, that he is dealing with a man who knows what he wants and who wants "figures" and not arguments.

Let this matter be sent to the manufacturer with a stamped envelope for its return, so that it can be sent to competing firms, or better, let several copies be made of the sketches and instructions, so each manufacturer may keep a set, and all be working on the proposition at once.

It should be insisted that the new machinery must do the maximum work, year in year out, for each dollar invested, and the maker should be asked to use plain, understandable words in his recommendations and guarantees. Nothing should be accepted that is not understood, and no hesitation should be felt to inquire into the why and wherefore of every little detail. This will prevent future sorrow.

Neither should there be any backwardness about requiring guarantees under bond. That the manufacturer is reliable and well established should be determined at the outset. New firms will be glad to be investigated thoroughly.

In this way the purchaser does not specify the machinery himself. The manufacturer does the specifying. Virtually the problem is put "up to him," which is logical, because all wide-awake manufacturers are well versed in all modern power-plant apparatus and will do as much for their customers as possible. It is not uncommon for firms to "turn down" orders and recommend competing apparatus. They would rather do this than have their own fail to perform better work than their competitor's. Being given conditions in detail, each manufacturer can tell quite accurately whether or not his machinery will be best and the purchaser will reap the benefit.

Small Leaks and Big Ones

In this week's leading article are the details of a remarkable saving made in a hotel power plant. The reduction in operating expense was enormous for a plant of its size. The machinery was new and should have operated at its highest efficiency, but it was the same old story of "the man behind the gun." The hidden losses were allowed to sap the vitality of the plant, little attention was given to operating schedules of the large machines and the auxiliaries, and apparently there was no effort to secure reasonable economy in the boiler room. Live steam was allowed to blow to the four winds. True it did it behind iron walls, but an investigation would have readily shown up this loss. The machinery was not kept in the best condition and it is clear that little effort was made to secure economical results.

All this was changed when a real engineer came on the job. Strict attention to duty was the rule. The hidden losses were detected and stopped, and at every possible point a saving was made. The boiler furnaces were remodeled and produced results sixty per cent. better. Operating schedules were carefully planned. Complete records were kept and interpreted by an engineer thoroughly familiar with his work. It is not surprising that a saving was made, but the size of it emphasizes the importance of stopping the small leaks and avoiding the big ones. The latter are usually visible, but the former require constant vigilance and attention to duty at all times. It is these small losses which in the aggregate determine the status of a plant and their detection the caliber of the engineer.

Ash Content of Coal

The relation between the ash content and the value of coal used as a fuel is a matter of special interest to power-plant engineers. Unfortunately, but little has been published in the technical press regarding the findings of those who have investigated the subject to determine the real value of the fuel supplied to the boiler furnaces.

Naturally, the freight charges have much to do with the final value of coal as a fuel, and there is no economy in purchasing coal containing 30 or 40 per cent. ash, upon which a high rate of freightage is charged and from which no heat value is obtained in return for the expenditure; there is also the cost of ash removal. Where power plants are close to the coal fields, coal with a high ash content would be worth considering.

In POWER of Sept. 22 there was published an article dealing with the question of ash, and on page 649 of this issue is another. It is interesting to compare the two findings as one article deals with anthracite and the other with bituminous coals.

Mr. Ellis found that the best results could not be obtained from coals having an ash content greater than fifteen per cent. He allowed one and one-half per cent. depreciation in the coal value for each one per cent. of ash content, and rejected as worthless any coal above fifteen per cent.

An article in the April 25, 1911, issue by A. Bement, analyzing the coal problem, gives valuable data concerning the ash content in coal.

Rate Decision

We understand that the New York Public Service Commission is about to render a decision relative to the rates of the New York Edison Co. This is the outcome of several complaints which have been pending for the past two years. The apparently slow progress has frequently been the subject of severe criticism, but, considered from all angles, Commissioner Maltbie is to be commended for proceeding cautiously in his endeavor to ascertain all the conditions and thus arrive at sound conclusions.

One noticeable feature of the hearings has been the apparent change in attitude of the officials of the Edison company, who, at first were almost dogmatic, but as the hearings proceeded gradually receded from this stand and began to show a greater willingness to coöperate with the Commission, especially in furnishing information.

With the complexity of service conditions in a city such as New York, the establishment of equitable rates is no easy task, but it is hoped that the decision will be such as to settle the question, and not make recourse to the courts necessary.

Even such a cold and chilled profession as that of the refrigerating engineer is affected by the war. The secretary of the International Association of Refrigeration announces that the publication of the *Bulletin* has been suspended, owing chiefly to lack of coöperation by those from the countries now engaged in hostilities.

Correspondence

Trouble with an Air Lift

In testing the capacity of each well separately, I found that they were not delivering the right amount of water. Like Mr. Lacy (page 504, Oct. 6), I lifted the air lines and found the same kind of a foot piece. I changed it, and increased the size of the air pipe to 1¼ in. from the air receiver to 150 ft. down the well. Then I put on a bull-head tee, 1¼x¾x¾ in., with two ¾-in. street ells, having ¾x¼-in. bushings and ¼-in. nipples 3 in. long, screwed into the street ells, making sure to turn the ells looking up. If Mr. Lacy will do the same I am sure he will have no further trouble.

MICHAEL A. QUICKER.

Belmar, N. J.

Steam-Gage Connections

On p. 427, Sept. 22, C. E. Anderson describes a change in the steam-gage piping. How would opening the blow-off cock remove the sediment in that gage pipe? It would drop down past the blowoff connection, settle in the bottom of the pipe, and could not be cleared without removing the gage and blowing through.

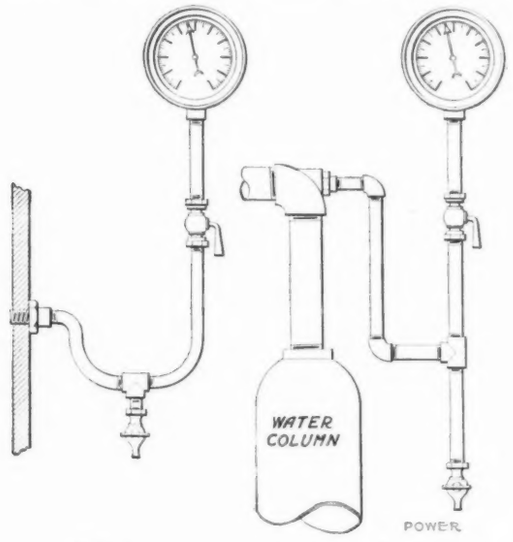


FIG. 1 FIG. 2

CUSTOMARY CONNECTIONS

The coil is of no use, as the trap in the pipe would protect the gage. A gage connection, as shown in Fig. 1, is considered good practice, and Fig. 2 is recommended by the Hartford Steam Boiler Inspection & Insurance Co.

FORREST R. CARPENTER.

Salmon Falls, N. H.

Without doubt, the drain-out cock was placed at the lowest point to drain out all particles of dirt or scale. The old connection is advised by boiler makers, insurance companies and inspectors as the best for all practical purposes.

If Mr. Anderson's new connection should happen to fill at the lowest point—and I cannot see what will prevent it—he will have to take off the steam gage to blow it out and, worse, he could not tell if it was filled until his gage did not work right.

The remedy is much the same as if his fireman should happen to leave the boiler blowoff open long enough to burn the plates or tubes and he should move the blowoff connection up a few feet.

BARCH SMITH.

Newark, Ohio.

Influence of Ash Content of Coal

In an address before the meeting of the National Electric Light Association in Philadelphia last June, Elbert Hubbard in substance said: "Darn the man that plagiarizes your thoughts before you have an opportunity to express them yourself." This is brought to mind by the article in the Sept. 22 issue on the "Influence of Ash Content of Coal," and the fact that I have purposed publishing the results of some investigations we have been making on ash content in coal.

As the article dealt with anthracite coal and our investigations considered bituminous coals exclusively, it may prove of interest to compare the results of the two findings. We undertook to ascertain the exact relationship between the ash content and the value of the coal under our conditions of operation. The relationship discovered is believed to hold closely in the average plant.

Most contracts for coal purchased upon the basis of its heating value are predicated upon the hypothesis that the value of the coal closely approximates the value indicated by the calorimeter. Practically all of such contracts seem to recognize that the ash content influences this value and they penalize an excess of ash. No contract under the writer's attention has attempted to penalize the ash content on any other than an empirical basis, and the article referred to is the first seen that has attempted the solution of the problem.

Our starting point was the proven fact, as stated in a bulletin of the coal-testing plant of the Government, that a coal with an ash content as high as 40 per cent. was worthless as it was difficult, if not impossible, to keep it ignited, in an ordinary furnace. We have had no such coals, but have had them approximating 30 per cent., and the results lead us to assume the correctness of the Government report.

Coal apparently follows a straight line characteristic, as regards its value in the calorimeter on a basis of its ash content, assuming the same character of coal, and a nearly straight line though at a different angle, as regards its usable value in the furnace. This last curve drops a little as the ash content nears 30 per cent., beginning to drop at about 20 per cent., and presumably this increases in curvature toward the point of zero

value. These results seem similar to those for anthracite coal in the previously mentioned article.

Since the personal equation of the fireman greatly affects the results obtained from the same coal on two successive days or different parts of the same day, it is difficult to keep all of the factors the same in a combustion test and the results are approximate at best.

It is also remarkable to note the closeness of the formula we have been using to evaluate our coal to the results obtained by Mr. Philo. Because the curve begins to drop rather rapidly between 20 and 30 per cent. ash and in practice we use coals having an ash content of 15 per cent. or less, we have settled upon 1½ per cent. depreciation in the coal value for each 1 per cent. of ash content; we reject as worthless for our uses any coal above 15 per cent. Were we closer to the coal fields, with consequent lower rate on coal freight, it would probably pay us to consider coals with higher ash content, but under our conditions we cannot afford to pay freight on the ash.

In practice, then, in estimating the probable value of coal, we use the formula:

$$value\ of\ coal = \frac{C + F + U}{B.t.u. - (B.t.u. \times 1\frac{1}{2}\ ash\ per\ cent.)}$$

where

C = Cost of coal at mine per ton;
F = Freight rate per ton;
U = Unloading cost per ton;
$B.t.u.$ = Heat value by calorimeter per ton.

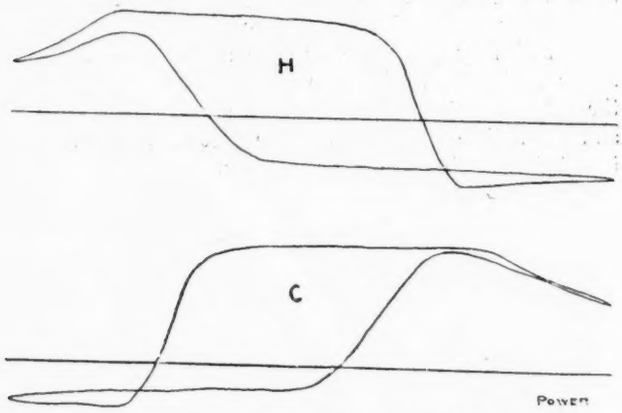
Considering the fireman and the inability to keep our conditions exactly constant, this formula gives us results as nearly correct as we can determine. In other words, the errors caused by its use are well within the errors of observation and measuring instruments.

R. L. Ellis.

Selma, Ala.

Indicator Diagrams for Comment

The accompanying diagrams were taken with a 50-lb. spring from the high-pressure cylinder of an 18 and 32 by 24-in. condensing engine running at 60 r.p.m. The engineer in charge says the engine is doing very good work, and gives no trouble except for a very heavy pound when the rod passes the centers. Can anyone tell what the trouble is as indicated by the diagrams?



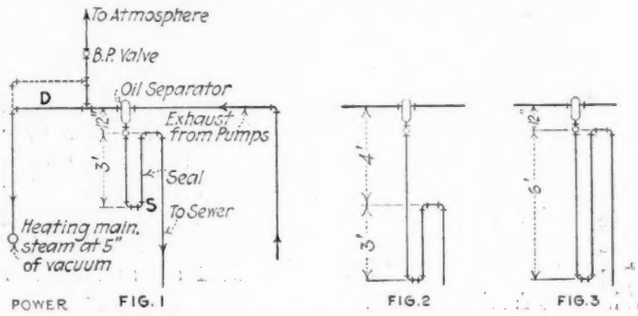
Head and Crank-End Diagrams from Steam Engine

Thomas McNamm.

Newark, N. J.

Oil Separator Failed to Work

An oil separator connected as shown in Fig. 1, did not remove the oil from the exhaust of a number of steam pumps in a case where 5 in. of vacuum, or 2.46 lb. below atmospheric pressure, was maintained on the exhaust steam main at the point where the separator was connected. Upon close examination the reason became apparent. The height from the bottom of the seal to the exhaust main was only 4 ft., so that only 4 ft. × 0.434 lb. = 1.736 lb. below atmosphere would lift this seal to a height where the oil could be swept into the heating system.



Seal for Oil Separator

Figs. 2 and 3 show how such a condition may be obviated, either of which arrangements will require a pressure of 6 ft. × 0.434 lb. = 2.6 lb. below atmosphere, to lift the oil in the steam to a height of one foot below the exhaust main. Further change should also be made in this piping for better oil separation as indicated by the dotted line at *D*, Fig. 1.

If the pressures were reversed in direction—i.e., if a back pressure of 2.46 lb. above atmosphere was carried on the exhaust main—then only 3 ft. × 0.434 = 1.3 lb. gage pressure would be required to blow out a seal such as shown in Figs. 1 and 2.

T. W. Reynolds.

Mt. Vernon, N. Y.

An Interesting Cylinder Failure

Under the above heading in Power of July 14, there is a description of an accident to an engine. The conditions at the time are stated and the deduction is made that water was pumped back from the receiver into the steam chest, which then cracked from over-pressure.

With the engine running forward and the valve-gear in a forward position, I do not see how water could be so pumped. Assuming that the piston is traveling toward the head end, and that the head-end exhaust valve is open and the steam valve closed, any water which might be in the cylinder would have a chance to escape through the exhaust valve until compression begins. If more than sufficient water is entrapped than will fill the compression space before the steam valve opens, then the cylinder head will likely be driven out, the connecting-rod bent, the crankpin broken, or the main bearing split. After the steam valve opens, the water can pass to the steam chest. But there will be mighty little of it, because the piston is about at the end of its travel when the valve opens. This process would be repeated at the crank end; therefore I do not see how sufficient water could be ac-

cumulated in the steam chest by the pumping process to damage it. The tendency would be to reduce the amount of water there.

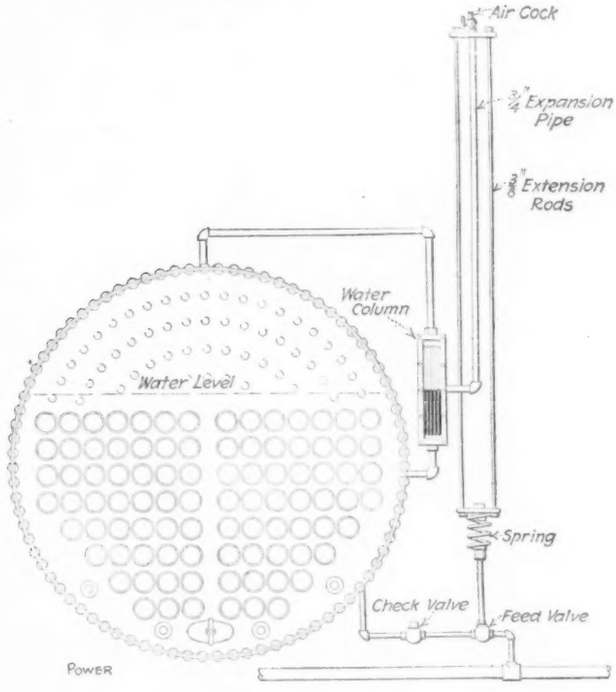
It looks more probable that the engine was stopped in such a position that both valves were closed and that the throttle leaked. Then when the chest was full of condensation, water-hammer cracked the chest. Of course, there would be noise from water-hammer and leakage from the engine, but what of that? The fact that the separator drain was plugged and the trap discharge valve closed shows that the motto of the plant was "In God we trust." If the engine were running backward with the gear in the forward position or if it were running forward with the gear in the backward position, we would have an almost ideal pump, but we have no evidence that such was the case.

R. McLAREN.

Medicine Hat, Can.

Home-Made Feed-Water Regulator

An engineer called my attention to his home-made feed-water regulators. He had made them out of odds and ends of pipes and rods about the plant and claims to have the simplest regulator in the world. I do not doubt his statement.



REGULATOR CONNECTED

He says they have never fooled him yet and he has perfect confidence in them. The illustration is self-explanatory.

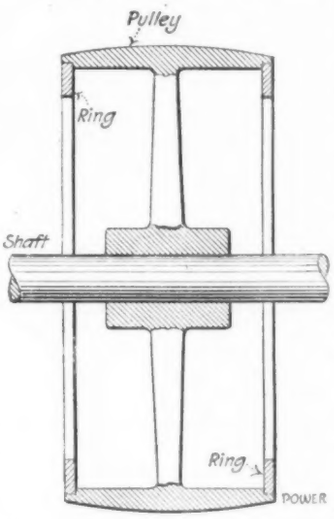
The process is one of balance, the feed valve is maintained in a certain position, feeding gradually and continuously maintaining an almost even level of water in the boiler. When the water lowers below the second gage cock, steam enters the "expansion pipe" and raises the rod, opening the feed valve. When the water in the column gets above this gage, water enters the "expansion pipe" and contracts it, pushing the rod down, thus closing the valve shutting off the water.

LUKE MATIER.

Fall River, Mass.

A Water-Cooled Pulley

Preparing to make a brake test on a small motor not long ago, I did not know where to get a water-cooled pulley in a hurry, so I made one out of a standard cast-iron pulley and a couple of welded wrought-iron rings. I first bored out the inner edges of the pulley rim, then turned the outside of the rings to make a driving fit, being careful, of course, not to make the fit so tight as to break the cast-iron pulley.



FLANGES FITTED TO PULLEY

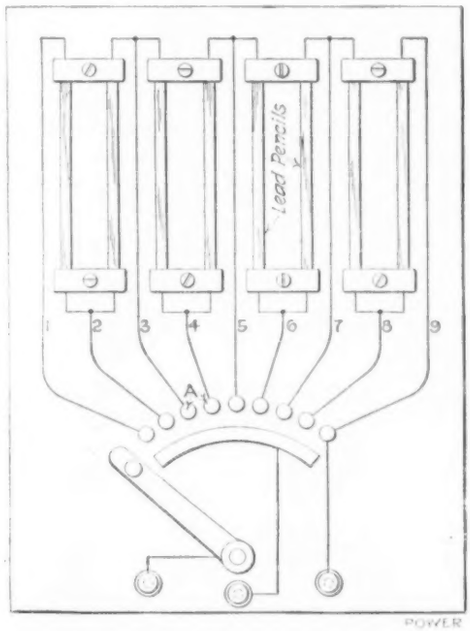
So far as I know, the pulley never gave any trouble. It leaked water a trifle at first, but rust quickly mended the leak.

S. F. WILSON.

New York City.

Lead Pencil Starting Rheostat

Once I had to temporarily install a two-horsepower motor and needed a rheostat for starting it, but did not have the necessary wire to make one. Therefore, I built up one, using ordinary carpenter's pencils for the resistance, as shown in the sketch. The results were very satisfactory.



HOMEMADE RHEOSTAT WITH LEAD PENCILS AS RESISTANCE

It consisted of a wooden board covered on one side by a sheet of asbestos on one face upon which rested the part that composes the rheostat. Standard porcelain cleats were used to hold the pencils and the end connections were made by wrapping a thin sheet of copper around the ends of the pencils. This copper, in turn, was soldered to No. 14 copper wire, the free ends of adjacent sections being joined. In order to avoid breakage of the lead by the pressure of the cleats, the ends were protected by asbestos cord.

The contacts, *A*, were fixed on the lower part of the board forming an arc of a circle and the ends of the wires 1 to 9 were attached to the respective contacts.

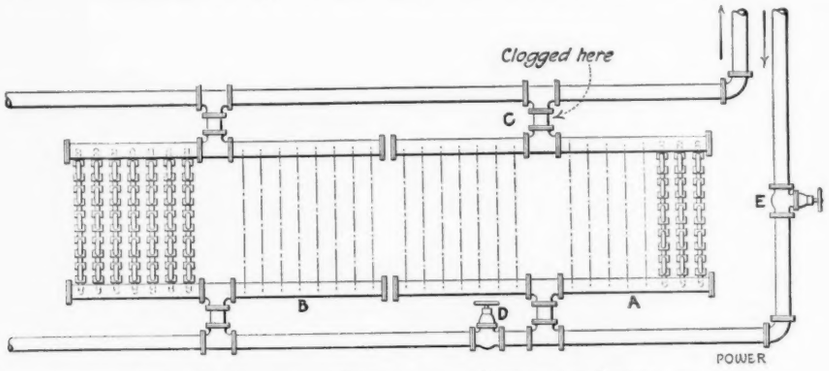
F. P. Ampudia.

New York City.

Condenser Trouble

The construction of one of our ammonia condensers is shown in the illustration. It is of the double-pipe design, having twelve pipes to the stand and two sections of 15 stands each.

When starting up this season, section *A* ran much warmer than section *B*, and the temperature would be practically uniform at top and bottom, when there should be about 20 to 30 deg. difference. In warm weather, the branch header and three or four pipes up from the bottom on section *B* would be sweating while the branch header on section *A* would be perfectly dry.



Arrangement of Piping and Point of Stoppage

We decided that section *B* was getting more than its share of the circulation, and put in a valve at *D* to throttle the supply to section *B*.

This proved unsatisfactory, because any attempt to throttle the supply to this section resulted in running up the ammonia head pressure and increasing the temperature of section *A*.

Finally, I put a gage at the top of one of the coils near the header and shut off valve *D*. The pressure instantly went up from 10 to 60 lb., the pressure carried at the pump. Evidently, the branch header at the top of section *A* was obstructed. When the caps on the ends of the branch header on section *A* were taken off and a rod run through it, a few particles resembling limestone were brought out. By hammering the branch outlet *C* several lumps came out, each large enough to practically obstruct the pipe.

The trouble was originally caused by a bad pipe allowing the ammonia to leak through into the water. The water used is from two artesian wells carrying a large amount of scale-forming matter which is deposited by the heat at the top of the condenser. When the ammonia combined with the scale, it formed the chalklike substance in the pipe. The defective coil was located close to the obstructed outlet and the deposit accumulated here until it filled the pipe. During the winter, while the condenser was shut down, it hardened to a solid mass and totally obstructed the outlet.

Thomas G. Thurston.

Chicago, Ill.

Engine- and Boiler-Room Signal System

It sometimes happens that there is lack of coöperation between the engine-room and boiler-room operators, caused by the failure of the former to give prompt notice to the latter in the event of a change in the demand for steam. It finds expression in the shifting of responsibility from one side of the wall to the other for the resulting low steam or bare grate surface. The engineer blames the water tender or man in charge of the boiler room for the drop in pressure, and the water tender blames the engineer for bare grates because he cannot tell when he may be called on for more steam. Aside from the unpleasantness arising from such conditions, it lowers the plant efficiency and affects the coal pile.

To secure the best results, the man in the boiler room must know at all times what is going on in the engine room and be able to anticipate changes in load. The following signal system has been successfully used as a synchronizer for these two departments by a large plant in the Middle West:

There are nine 900-kw. units in the engine room, each represented by an incandescent bulb in the boiler room and so connected that when the switch is thrown at the board, cutting a generator in on the line, a circuit is closed with the light in the boiler room and the lamp remains bright till the switch is pulled and the generator taken off the board. The lamps are inclosed in a long box having frosted glass sides and nine compartments, each numbered to correspond with the unit which the light within represents, so that at any time the boiler-room operator may tell at a glance the number of engines steaming and instruct his firemen accordingly.

In addition to this, there is a gong system which serves as a warning to the water tender or man in charge of the boiler room when there is to be a change in load due to the shutting down or starting up of one or more engines. One ring means that less steam will be required after the change, and two rings that more will be necessary. The warning is given, if possible, at least half an hour before the change in load occurs.

Such a system is fairly complete, and enables the boiler-room operator to keep in touch with things in the engine room and run the boilers more efficiently. When the value of such systems is realized, one wonders why they are not more generally used.

A. W. Conklin.

Wyandotte, Mich.

Preheating Furnace Air

Mr. Olmstead's letter on page 24, July 7, (see also Aug. 4, page 179, and Aug. 11, page 217) recalls a time I wanted to try a system somewhat similar, employing waste exhaust steam. After comparing the cost and the benefits I gave it up.

In marine practice the Howden system, in which the furnace air is heated by tubes in the uptake, is quite old. Due to the high temperature of the flue gas the air is raised to 300 deg. or over, and combustion is very rapid, but the grates burn out in a short time. High furnace temperatures cause clinker, while the same coal if burned in an ordinary furnace is satisfactory.

Many Howden preheaters operate economically, though it is necessary to keep the air temperature lower than Howden first planned.

A scheme devised for torpedo boats consisted of a water-tube boiler similar to the Thornycroft. On the outside an iron casing conducted the air to the grates, the object being to recover most of the heat usually lost by radiation, and incidentally to cool the fireroom.

That any system employing waste heat is economical is not to be questioned, but it is doubtful if the cost of installation, maintenance and depreciation is justified unless, perhaps, in sections where coal is expensive, and even then the economizer seems preferable.

WILLIAM E. CALDWELL.

New York City.

In the system of preheating air described on page 179, Aug. 4, a fan is so arranged that the air used for combustion is drawn from over the boilers. It is claimed that much coal is being saved, but I believe that except

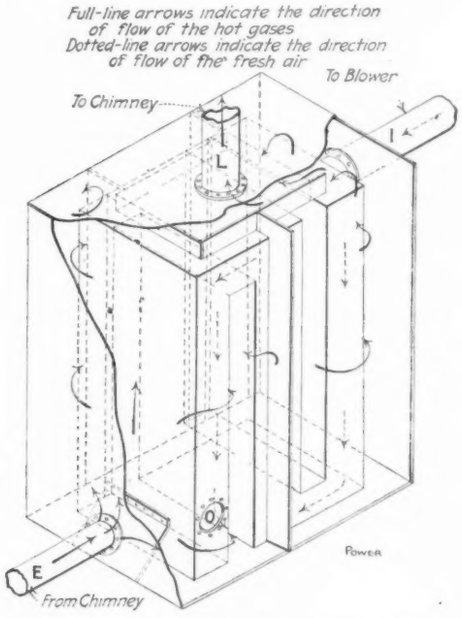


FIG. 1. CONSTRUCTION DETAILS OF HEATER

for ventilating the boiler room, such a system is useless, if not wasteful.

The heat in the boiler is derived from the coal, and unless the surface of the boiler is covered with some nonconductor, a great deal of the heat in the steam will be lost by radiation—and imagine how much more when comparatively cold air is continuously passing over the boiler. Of course, some heat is returned to the furnace, but there is a loss just the same.

A system for preheating air by utilizing the heat that otherwise escapes through the stack is here suggested: Fig. 2 shows the heater *H* in connection with an ordinary tubular boiler. The fan blower *B* is connected to the

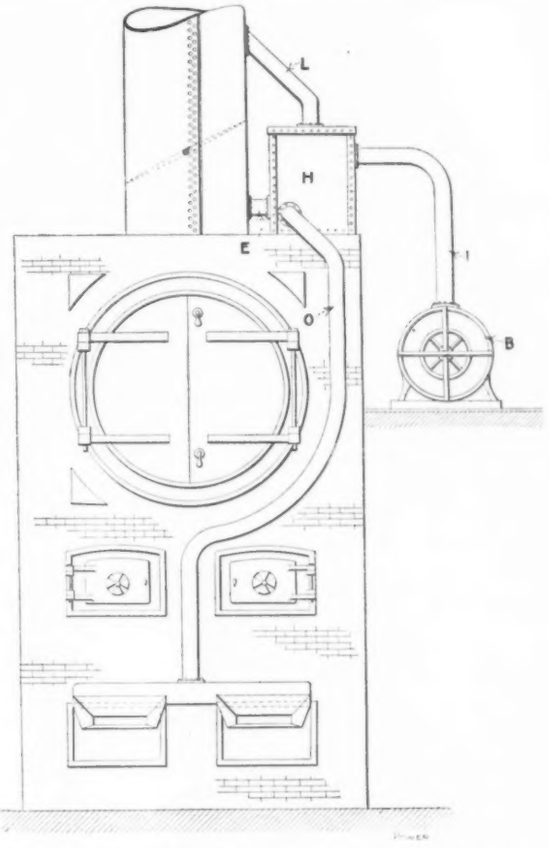


FIG. 2. GENERAL OUTLINE OF AIR PREHEATER

heater by the pipe *I*, and *O* is the pipe leading from the heater to the ashpit. Pipe *E* connects the heater with the breeching, the point of connection on the latter being a little below the damper, and the hot gas, after passing through the heater, returns to the breeching through the pipe *L* above the damper.

Fig. 1 shows the internal arrangement. The air from the blower, entering at *I*, passes through and escapes through *O*. The hot gas from the breeching enters at *E;* impinges against the baffle-plates, then takes the course shown by the full-line darts in such a way that every part of the surface is heated by the gas coming directly in contact with it.

A wire screen secured to the breeching end of the pipe *E* will keep out the cinders that would otherwise settle inside of the heater. The air line *I*, being comparatively large, reduces the air velocity as it enters the heater, thereby permitting it to remain in the heater long enough to absorb a large amount of heat.

As the gases in the breeching usually have a temperature of 350 to 650 deg. F., it is easily seen that the air for combustion will be given a very high temperature, not at the expense of the heat that should be put into the steam but by reducing the stack temperature.

The heater is simple and may be constructed of ⅛-in.

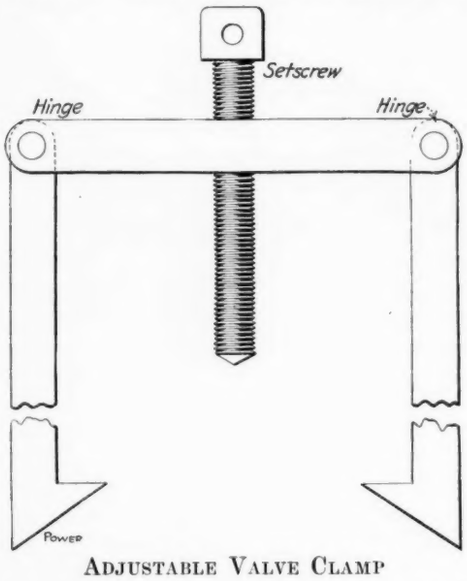
galvanized iron and $\frac{1}{16}$-in. iron would be heavy enough for pipes *I* and *O* to give lasting service. One or two handhole plates at suitable points would be useful.

SAMUEL L. ROBINSON.

Providence, R. I.

Clamp for Safety Valve

A clamp for a safety valve to prevent it opening when applying a hydrostatic test to a boiler is shown in the illustration. The clamp is placed over the valve, the arms hooked under the valve body and the setscrew set down



ADJUSTABLE VALVE CLAMP

on the spindle preventing the disk from lifting. This saves the trouble of increasing the tension on the spring and resetting to the right pressure after the test.

W. WRIGHTSON.

Jamaica, L. I., N. Y.

Uniform Boiler Legislation

The publicity given the enactment of uniform license and boiler laws through agitation by engineering societies should arouse sufficient interest among public officials to cause the passage of sound uniform rules and regulations governing the construction and operation of steam boilers.

Every now and then we hear of an explosion caused by some negligent employee or employer allowing a boiler to be operated in an unsafe condition, either unknowingly or hoping that the boiler would pull through the season without having to spend money to put it in good shape.

Such a condition came to my attention when we were called to make a report on a plant from which severe complaints regarding the fuel had been received. An investigation showed that the boiler tubes were very dirty, the combustion chamber full of ash, even touching the boiler shell, the bridge-wall covered with clinker and with but little space between it and the shell; the air spaces in the grate were plugged with clinker and melted glass, the safety valve, of the lever type, was stuck fast and the blowoff connections looked as though they would fall apart.

The engineer has been there months and had not "discovered" that the grates were of the shaking type; neither had he initiative enough to open the boiler to examine the interior. These conditions existed in a woman's home, a semi-charitable institution where a large number of people were housed, and all subject to the results obtained by an incompetent boiler operator.

In such cases, enactment of laws would be of little benefit; enforcement is what we really need.

J. B. HARRIS.

Minneapolis, Minn.

Allowance for Expansion

Like E. R. Pearce, on page 465, Sept. 29, I have seen a bronze bearing heat sufficiently to slow down a 125-hp. engine and freeze to the shaft almost instantly.

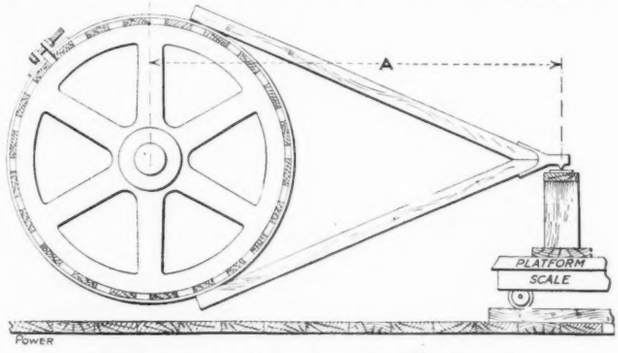
It was on a 40-kw. generator and it was a strict rule to make sure that the oil rings had begun to revolve immediately after starting the engine. This was done as usual when the engine was started at 12:50, and before the load came on at 12:55, the engine suddenly slowed down to less than half speed, accompanied by the screeching of belts. The engineer threw out the clutch driving the generator. Upon examining the bearing it was found that but little damage had been done to it or the shaft, although it was necessary to use a jack to get the bearing off the shaft. The oil well was full of clean oil and no defect could be found in the ring, which was revolving properly less than five minutes before. This bearing, to my knowledge, ran perfectly before this and for two years afterward. The strangest feature was that the bearing seized the shaft so firmly without seriously damaging itself or the shaft, the generator being shut down only four hours as a result.

I. S. CHAMBERLAIN.

Jersey City, N. J.

Prony Brake

When making a prony brake it will simplify the calculation if the arm is of such length that the distance *A*, in the illustration, is 63.024 in., or the radius of a circle the circumference of which is 33 ft. If *W* equals the



LENGTH OF ARM AFFECTS FORMULA

weight on the scale and *N* the revolutions.

$$hp. = \frac{2\pi AWN}{33{,}000}$$

will be simplified to

$$hp. = \frac{WN}{1000}$$

M. E. GRIFFIN.

Franklin, Penn.

Engineers' Study Course

Problems in Power-Plant Design--III

Power for Lighting

In a previous article, the capacity and size of the main generating set for supplying the entire plant with power was determined. The next step is to make similar computations for the lighting plant. As already stated, the details of this part of the work will not be included in the problem, our attention being confined to supplying power for the same. If the lighting requirements are given in watts, the capacity of the generator in kilowatts is found by dividing this quantity by 1000, and increasing the result a small amount, say 5 per cent., for transmission and other losses.

Sometimes a list of lamps for the entire plant is given, with the current in amperes required by each. In cases of this kind, the total number of amperes multiplied by the voltage of the system will give the watts, from which the capacity of the generator may be found as before. If no data are given, and the power must be approximated from the plans, we may proceed as follows:

First, assume the lighting requirements in each building, and decide upon the type of lamp to be used; then assume the candlepower or watts required per square foot of floor space, and work out the requirements along this line from dimensions given on the plans. All results should finally be reduced to watts, and from the total thus found the capacity of the generator can be determined as previously described. In general, erecting shop, foundry, forge shop, power house, storage space, etc., are best lighted by arc lamps, supplemented by incandescent lamps at special points if needed. In the case of the machine and pattern shops incandescent lighting is preferable on account of the absence of shadows and the ability to concentrate the light at the point most needed. Incandescent lighting is also employed for offices and drafting rooms for the same reasons, and for the softer quality of the light. For outside lighting the arc lamp is generally more satisfactory. As the power of arc lamps varies so much under different conditions, it is customary to give the requirements in watts per square foot of floor space when making approximations of this kind.

In the case of incandescent lighting, candlepower per square foot of floor space is commonly used, allowing about 3½ watts per candlepower for lamps with carbon filament and 1¼ watts for the tungsten lamp. For average conditions, the following requirements, taken from "Power, Heating and Ventilation," may be assumed: For dwelling houses, with brilliant illumination, one candlepower may be allowed for each 2 to 3 sq.ft. of floor space and for general illumination, one candlepower for each 4 to 5 sq.ft. of floor space, strengthened by special lamps where required. In the case of offices, public halls, etc., one candlepower is required for each 3 to 4 sq.ft. of space for ordinary conditions, while for brilliant illumination, or where ceilings are very high, this should be reduced slightly.

Drafting rooms require one candlepower for each 1.5 to 2 sq.ft. of floor space to give the best results. The efficiency of 3.5 watts per candlepower is for the ordinary 16-cp. carbon light when new.

While some of the newer types of lamps have a higher efficiency, this is on the side of safety and may be used for approximate work in case the particular type of lamp is not known. In case of arc lighting, Table 1 may be used for approximating the current required.

TABLE I

Building or Room Lighted	Watts per Sq.Ft. of Floor Space
Machine shop	0.75
Foundry	0.6
Forge shop	0.6
Erecting shop	0.6
Storage space	0.4
Power house	1.0

Multiple-arc lamps would probably be used in the present case, as they can be run at the same voltage as the incandescent lamps. These are made in different sizes; the standard 110-volt lamps of the General Electric Co., take 4, 6 and 7.5 amp. each.

Taking up the different buildings and departments, we find from the plans the following floor space to be lighted:

ARC LIGHTING

Erecting space in machine shop, sq.ft	16,000
Foundry, sq.ft.	15,000
Forge shop, sq.ft.	5,000
Storage space, sq.ft.	14,000
Power house (estimated) sq.ft.	5,000
Carpenter and paint shops, sq.ft.	3,000
Ten outside lamps.	

INCANDESCENT LIGHTING

Machine shop, sq.ft.	24,000
Tool room, sq.ft.	4,200
Pattern shop, sq.ft.	4,200
Drafting room, sq.ft.	4,200
Offices, sq.ft.	4,200

Under arc light, the different departments may be classified as follows:

	Erecting space, sq.ft.	16,000
	Foundry, sq.ft.	15,000
	Forge shop, sq.ft.	5,000
(1)		36,000
(2)	Storage space, sq.ft.	14,000
(3)	Power house, sq.ft.	5,000
(4)	Carpenter and paint shops, sq.ft.	3,000

Taking the watts per square foot of floor space for the different departments from Table 1, and assuming the requirements in the carpenter and paint shops to be the same as for a machine shop, gives:

(1)	36,000	×	0.6	21,600
(2)	14,000	×	0.4	5,600
(3)	5,000	×	1.0	5,000
(4)	3,000	×	0.75	2,250
	Total watts			34,450

To this must be added the current required for the outside lighting. Assuming the lamps to be the equivalent of those requiring 6 amp. on a 110-volt circuit, we have the following requirements for this purpose:

Taking up the incandescent lighting on a candlepower

$$110 \times 6 \times 10 = 6600 \textit{ watts}$$

basis, we have

	Machine shop, sq.ft.	24,000
	Tool room, sq.ft.	4,200
	Pattern shop, sq.ft.	4,200
(6)		32,400
(7)	Drafting room, sq.ft.	4,200
(8)	Offices, sq.ft.	4,200

Computing the lighting of group (6) on a basis of 4 sq.ft. of floor space to one candlepower; group (7) on 1.5 and group (8) on 2 sq.ft. per candlepower, and assuming an efficiency of 3.5 watts per candlepower gives:

(6)	$\frac{32,400}{4} \times 3.5 =$	28,350
(7)	$\frac{4,200}{1.5} \times 3.5 =$	9,800
(8)	$\frac{4,200}{2} \times 3.5 =$	7,350
	Total watts....	45,500

The total for the plant would be

$$34,450 + 6600 + 45,500 = 86,550 \text{ } watts$$

which, after allowing a 5 per cent. line loss, calls for a generator of practically 90-kw. capacity.

In buildings like the foundry, forge shop, etc., it has been assumed that the entire lighting will be done by arc lamps, when, as a matter of fact, a considerable number of incandescent lights will be used in each case. This, however, will not affect the result to any appreciable extent and simplifies the process of computation somewhat. The next step is to decide upon the number of units to use and the method of proportioning the power among them.

As the lighting load in a plant of this kind is light during the day, and is at a maximum for only a short time at morning and night, it is desirable to have several units so arranged that as the load increases their power may be successively added as required. The relative size of the units is a matter upon which there is some difference in opinion. While the best economy is secured where large machines are used during periods of heavy load, and those of small size during light loads, certain practical considerations may lead to a different course. It is the custom of many engineers to divide the total capacity into three units of such size that any two of them by running at 20 to 25 per cent. overload, can do the entire work satisfactorily. This permits of shutting down one unit in case of repairs, and also the three are interchangeable on the work. With this arrangement only one set of repair parts need be kept on hand, which is often a matter of some importance.

In some cases the power is divided among three units of equal size, designed to do the work at their normal capacity, and an extra unit of the same size provided for use in case of an emergency. This allows for a spare machine at all times and allows for a "rotation" in the use of the different units.

A good arrangement in the present case would be to provide three units, one of 60-kw. capacity, and two of 30 kw. each. The larger machine and one of the smaller ones would do the regular work, and leave a spare machine of the smaller size. In case of repairs to the larger unit, the two smaller ones could be used and the remainder of the load be thrown upon the main power generator which is provided with a certain amount of surplus for this purpose.

Having decided upon the sizes of the generators, the next step is to determine the indicated horsepower of the engines for driving them. This depends upon the efficiencies of the engine and generator, and is given by the formula:

$$i.hp. = \frac{kw. \times 1000}{746 \times A \times B}$$

in which

$i.hp.$ = Indicated horsepower of engine;
$kw.$ = Kilowatt rating of generator;
A = Efficiency of engine;
B = Efficiency of generator.

For full loads, under ordinary conditions, we may assume an efficiency of 80 to 85 per cent. for engines up to 100 i.hp., and 85 to 90 per cent. for larger sizes; and efficiencies of 85 to 90 per cent. for generators up to 100 kw., and 90 to 95 per cent. for larger machines. Taking the higher efficiencies given above, the indicated horsepower of the engine equals the kilowatt rating of the generator times 1.75 for generators up to 100 kw., and kw. $\times$ 1.57 for larger sizes. Applying these relations to the case in hand gives

$$30 \times 1.75 = 53 \text{ } i.hp.$$

for the small units and

$$60 \times 1.75 = 105 \text{ } i.hp.$$

for the larger one.

Unless the exhaust can be utilized for heating purposes, the compound engine will show a considerable economy over the simple engine. In the present case, the compound engine would seem to be preferable. A rough estimate makes it appear that the exhaust from the main engine will be sufficient for all heating and ventilating purposes and that the exhaust from the lighting engines will be wasted.

Tandem engines seem well adapted to the comparatively small sizes called for, and will be used in the present case. The exact dimensions will depend upon the make, but will be approximately 8 and 12x12 in. and 10 and 16x12 in. for a pressure of 120 lb., which was assumed in case of the main engine.

Detecting Ammonia Leaks

By Robert G. Thurston

Leaks are common about any refrigeration plant because of the difficulty in maintaining a system tight. If long continued, a few small leaks mean the loss of considerable ammonia which, of course, must be made up by adding a new charge. For the parts of the system not in water or brine, the writer finds that sulphur sticks are the best means for finding leaks.

Making Sulphur Sticks

Sulphur sticks may be made in several ways. The sulphur may be purchased at a drug store or of a dealer in chemical supplies, after which it remains to melt it preparatory to making the sticks. The sulphur should be put in any kind of metal can or pan and placed on an uncovered engine cylinder or on an iron plate heated by a blacksmith's forge or by a gasoline torch. If it is melted over an exposed flame, there may be trouble by the sulphur catching fire. For sticks, the writer generally uses candle wick, twisting and doubling it over once, cutting it in one foot lengths and dipping it in the molten sulphur, after which the wick is laid on a board to harden.

Another method is to dip pine sticks about the size of a lead pencil in the sulphur to within three inches from one end. Tubes of asbestos paper plugged at one end with a cork, with asbestos mortar or a piece of pipe covering, form a good mold for sticks of ½ to ¾ inches in diameter and about a foot long.

For testing, light the stick and bring it close to every joint where there is any possibility of leaks. When there is ammonia present the sulphur fumes from the stick will instantly form a white smoke indicating the leak. With a little experience one can find leaks with little trouble. To keep the sticks from burning too fast, dip them in water up to the flame; this may have to be done several times with each stick.

If the atmosphere contains much ammonia, or if there is considerable moisture in the vicinity of the leak, the inexperienced man may have trouble in finding the leak as the moisture absorbs the ammonia, making it appear that ammonia is coming from all moist parts.

Generally, if the leak is bad and the sulphur flame is brought close to it, a white precipitate is formed where the gas is escaping. As the fumes naturally flow upward, the stick should be held under and two or three inches away from the place being tested.

Leaks and joints submerged in brine or water cannot of course be tested in this way, but they may be tested with litmus paper on Nessler's solution.* If ammonia is present in water or brine it will turn the litmus paper red, while a few drops of Nessler's solution added to a sample of the brine or water will show a yellow discoloration for slight traces of ammonia, increasing to brown as the amount of ammonia increases. Litmus paper or Nessler's solution may be had from any chemist or dealer in chemical supplies or from ammonia makers.

In testing for leaks in a brine tank it is best to stop the circulation for a short time and allow the brine to become quite saturated with the ammonia.

In a double-pipe condenser, one coil should be cut out at a time; let it stand a little while and drain it, testing the water that drains out. Of course, if there are any large leaks they will show in the return water from the condenser when tested. An atmospheric condenser can be examined for leaks by testing the return water or by shutting off the water on one coil at a time until the water dries off, after which the leaks may be found with the sulphur sticks.

Water jackets on the compressor should also be tested, the same as those of the condensers and brine tanks. It is good practice to go over the whole system every week, and by so doing the result will be best noticed in the reduction of the ammonia bill for the year.

The greatest sources of ammonia loss are in the compressors, the discharge tanks, the condenser, and its valves. Expansion valves and the stop valves on the machine which are used regularly are especially likely to leak as they are operated frequently. Leaks in the discharge line are caused by variation of the temperature to which it is subjected. It is not uncommon to find the discharge line over 250 deg. when pumping out parts of the system, and, when the machine is again in regular operation, it may drop down as low as 70 or 80 deg. This naturally means that the joints are loosened more or less and leaks begin and grow. Condensers generally start leaks when they are shut down or have been running warm. The condensing water soon brings them down to the temperature of the water, and the change loosens the joints and starts the leaks. Therefore, it is good practice to shut off the water if the condenser is cut out for any length of time and let it cool down gradually.

*For directions for making Nessler's solution see "Power," Mar. 31, 1914, p. 450.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

"Wheriver ye see a head, hit ut!" was Kilkenny's slogan in days of old. 'Tis a pity that some of these ancient "blue laws" are—well, you know what you'd like to do when you meet up with a sour guy stuffed full of pessimism. Be a real feller, and kid yourself that times are the best ever, even when they look at their worst. It's a good way to help make them good.

"Bud" Fisher has a muttandjeff that goes like this:

Jeff—I see they're firing on the United States battleships now.

Mutt—G'wan, you're crazy; this is a neutral country.

Jeff—I can't help that, they're firing on the U. S. ships just the same.

Mutt—Where?

Jeff—All over the world.

Mutt—Who's firing on 'em?

Jeff—The stokers.

Over a hundred mayors of the big and little cities will meet in Philadelphia soon. They have organized a utilities bureau to pull their bailiwicks out of the slough that is holding down the common people as regards their light, heat and power. When folks can get a fat little 15c. kw.-hr. dressed for the market for four or five cents, mebbe the boss will put part of the difference in our pay envelopes. Heat, light and power have a whole lot to do with our getting anywhere.

And, anyhow, the heads of our big cities are wising up to the utility of running them on sound business principles Here in New York village, a five-thousand-dollar feller got a job along the executive line through an ad in the paper. Think of it! They skipped the political high tiger spots and didn't even inquire under what emblem he voted. He was picked on his merits and had the goods. Patronage-ridden cities, please take notice.

The oil engines of war are not running to the taste of those big sea-plant engineers, U. Sam and J. Bull. As this oil is said to be standard it ought to still the troubled waters between Sandy Hook and chalky cliffs of Albion. There's a hot bearing somewhere in the political machine.

What's all this about making cotton more popular? Can't get too much of it in the power plant, even if it mostly runs to waste.

The Pennsylvania Railroad System has offered to carry free of charge to New York docks all gifts intended for the Belgian orphans and refugees of the European war. Bully! This lively little concern is always coming to the front with a shop kink that disproves the assertion that corporations have no soul or bowels of compassion.

Along in December there's going to be an international exposition of inventions in New York. It will be a show to give the inventor a show. If you have something new and useful, wrap it up and tote it in to the Grand Central Palace on Dec. 12 to 19. You can meet men with real money who will exploit it for you if it's the right kind of goods. Mebbe you are a Hargreaves, or an Arkwright or a Whitney, and don't know it.

Our old friend Mel Mix, of the Dodge Co., has again tuned his lyre to the "Safety First" madrigal. Mel hits the high C and gets away with it when he carusos that "safety first is a matter of dollars and cents," even if it does sound cold-blooded. But dollars and cents mean just as much to the boss as to the workman; it's profit and loss whichever way you regard it. And safeguarded machinery earns a big profit.

Let's Mix it some more. Mr. Mix says that to be able to sell, say, power-plant machinery to South America, we should first send down our buyers and put some capital in South American hands; theirs has been tied up by the war. Buy something, and then you can readily sell something. Not a bit mixed is Mix; he has the right idea.

Chain Grates under Stirling and Vertical Boilers*

By Osborn Monnett†

SYNOPSIS—Length of grate, type of arch, extension and dimensions of gas passes, which tend toward smokeless operation. Instructions on operating a chain grate without smoke.

One of the fundamental requirements of a good setting under a Stirling boiler is that the grate should not be set flush front, but should be extended in front of the boiler sufficiently to give a good igniting action. It has been demonstrated that an ignition arch less than 5 ft. long will not show good all-around results. Taking 5 ft. as the minimum length allowable, gives an extension of from 2 ft. 6 in. to 3 ft. on this type of setting.

Fig. 1 shows a representative Stirling boiler setting

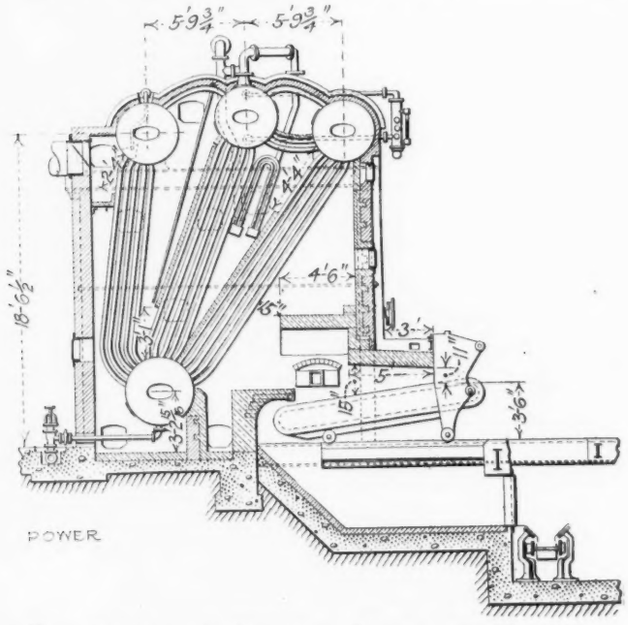


Fig. 1. Class S Stirling Boiler, 375-Hp., and Inclined Green Chain Grate

with a 5-ft. ignition arch followed by the standard Stirling arch. This setting, which has an inclined grate, is good for normal capacities. The inclined grate works out well, not only for the Stirling boiler, but for any type of boiler, as it allows more volume under the arch for combustion. One point to be watched in chain-grate installations is the length of the grate. A short grate will give trouble on high capacities. There is a time in the life of nearly every boiler plant when it is necessary to push the stokers to the limit. When this time comes, a short chain grate will smoke badly, and will also deposit live coals in the ashpit.

Many old Stirling settings have been set flush front with short grates, using 3½-ft. arches. Such installations cannot be considered satisfactory. All things considered point to a grate with a 9 ft. 6 in. active surface (gate to water back) as the best for general use. This allows the boiler to be run at ratings up to 25 to 50 per cent. overload without distress in the furnace. With plants designed for high overloads (up to 100 per cent. overload), the grates must be longer. Fig. 2 is a typical installation with a 5 ft. 9 in. ignition arch and horizontal stoker, while Fig. 3 shows an inclined stoker without a water-back. Both of these settings are good for normal capacities.

In Fig. 4 the arch is set 15 in. high at the gate and

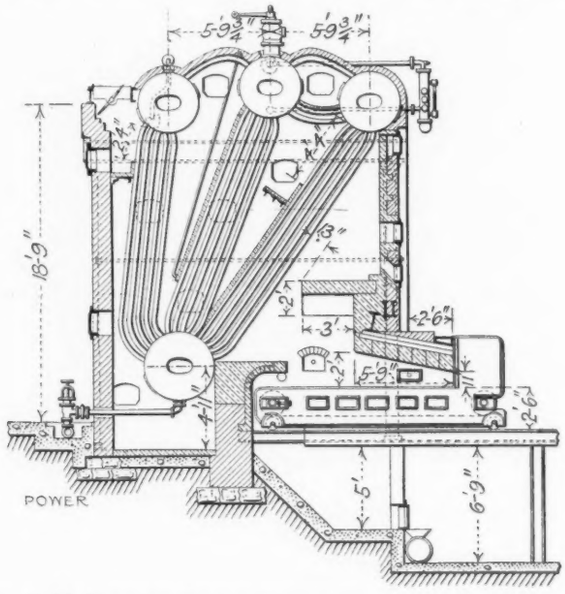


Fig. 2. McKenzie Chain Grate under 315-Hp. Class S Stirling Boiler

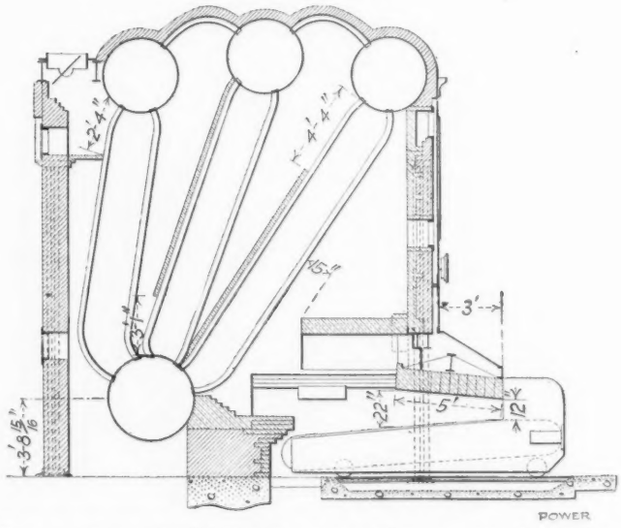


Fig. 3. Class S 500-Hp. Stirling Boiler and Laclede-Christy Inclined Chain Grate

inclines 3 in. to the foot. Fifteen inches can be taken as a good standard gate height for flat arches, as it shows much better ignition than the old standard of 11 in. There are instances, however, where the slope of the arch

*Copyright, 1914, by Osborn Monnett.

†Smoke inspector, city of Chicago.

can be brought down to 1½ in. to the foot with advantage. This setting easily cares for moderate swings in the load without distress, and is smokeless at all reasonable capacities. It was designed for a continuous overload of 100 per cent. The center of the mud drum is set 5 ft. above the floor line, giving room for the grate without unreasonable extension, and at the same time delivering the heat to the lower part of the front bank of tubes, so that no heating surface is sacrificed. The high-pressure water-back provides a permanent bridge-wall, requiring little maintenance expense, and the flame travel is sufficient to take care of the gases at high capacities. The following record of a test run on this unit shows that at a capacity of 941 hp. (88 per cent. over-

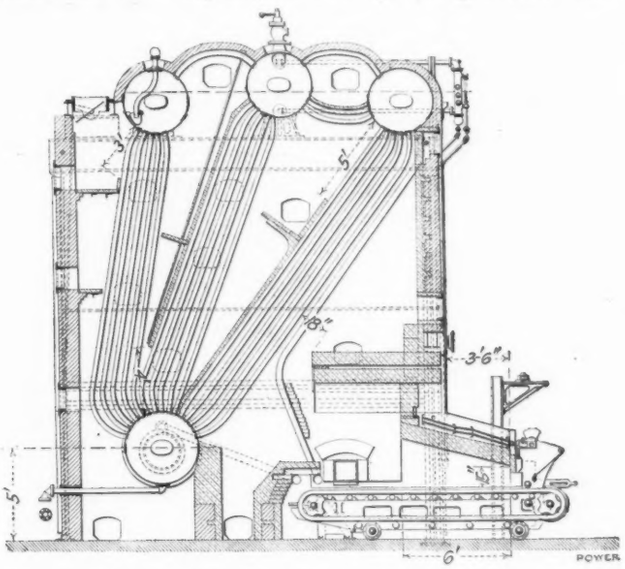


FIG. 4. CLASS O 500-HP. STIRLING BOILER AND GREEN CHAIN GRATE, DESIGNED FOR 100 PER CENT. CONTINUOUS OVERLOAD

load), the efficiency was 68.4 per cent. when burning Harrisburg screenings:

BOILER TRIAL IN CHICAGO PLANT

Stirling boiler	7-29-14
Sq.ft. of grate surface	99
Effective heating surface, sq.ft.	5016
Ratio of grate to heating surface	50.66
Factory rating in hp.	502
Method start and stop	Alternate
Duration in hours	5
Kind of coal	Harrisburg Screenings
Draft at stack, in. of water	1.35
Draft at damper, in. of water	0.59
Draft over fire, in. of water	0.42
Position of damper	Full Open
Depth of fire in inches	6
Speed of grate, in. per min.	4
Average temp. of flue gases	682
Average steam pressure, lb. gage	137
Average temp. of boiler room	84
Average temp. outside	80
CO_2 readings in per cent.	8.2
Lb. coal consumed	18,200
Per cent. of moisture in coal	5
Lb. coal consumed and corrected for moisture	17,290
Lb. coal sifted through grates and used over again	1045
Lb. ash	3310
Per cent. of dry coal to ash	19
Per cent. of coal fired, combustible	77
Lb. water evaporated	136,875
Factor of evaporation	1.187
Equiv. water evaporated f. and a. 212 deg.	162,399
Lb. water evap. f. and a. 212 deg. per lb. of dry coal	9.392
Lb. water evap. f. and a. 212 deg. per lb. of coal as fired	8.923
Av. hp. developed per hour	941
Lb. dry coal burned per sq.ft. grate per hr.	35
Lb. coal as fired per sq.ft. grate per hr.	36.8

CHEMICAL ANALYSIS OF COAL

Moisture, per cent.	4.84	Dry Basis
Volatile carbon, per cent	24.74	26.00
Fixed carbon, per cent.	62.26	65.42
Ash, per cent.	8.16	8.58
Sulphur, per cent.	4.20	4.41
B.t.u. per pound	12,650	13,300
Boiler efficiency based on coal as fired, per cent.		68.45

Another type of Stirling setting which can be adopted with advantage under certain circumstances is shown in Fig. 5. This consists of an Illinois stoker with a single arch 8 ft. 8 in. long, covering the grate entirely, set high and pitched 3 in. to the foot. On reconstruction jobs, where it is desired to improve the smoke conditions on a flush-front setting, this type of arch will work out satisfactorily for ordinary capacities. In Fig. 5, the stoker has been set with 3 ft. 11 in. extension to make

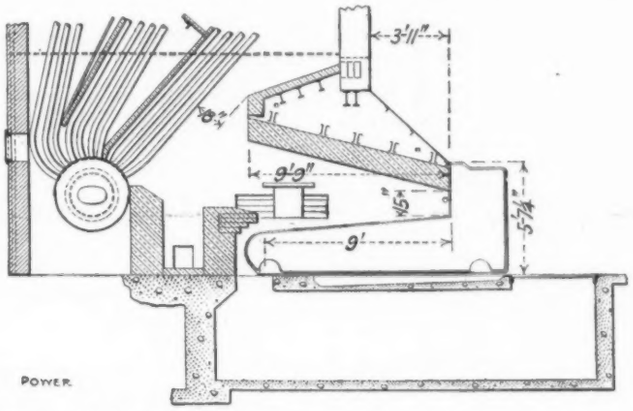


FIG. 5. A 260-HP. STIRLING BOILER WITH A SINGLE ARCH OVER AN ILLINOIS STOKER

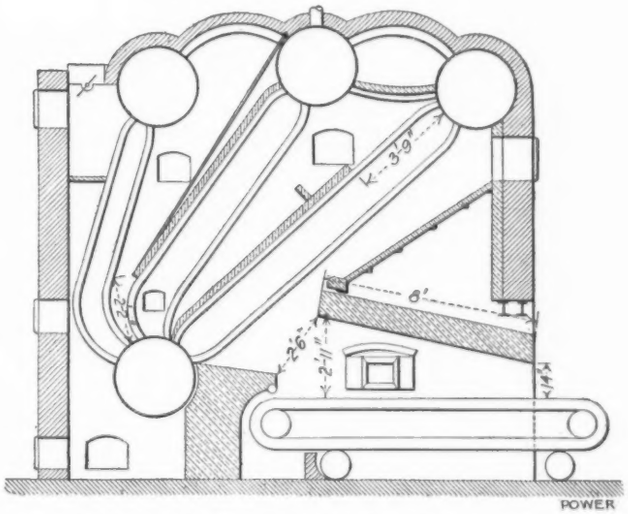


FIG. 6. STIRLING BOILER AND FLUSH FRONT STOKER FITTED WITH SINGLE ARCH

sure that plenty of ignition and flame travel will be provided before the gases strike the heating surface. At the same time, the stoker is of the inclined type, which further increases the flame travel.

Such an arch set over an old flush-front stoker can be made to increase the steaming capacity of the boiler, provided sufficient draft is available. In overhauling an old setting of this kind, it will be necessary to look carefully to the baffles, as invariably they will be found restricted. The combination of raising the arch and making it in one span, and the opening up of the baffles, will do wonders in increasing capacity and smokeless operation on these old settings. Fig. 6 is a typical example.

The same principles apply to other types of vertical boilers, although in general the flame travel is somewhat longer. Fig. 7 shows a chain-grate setting under a 312-

hp. Erie City vertical boiler, in which the ignition arch is 6 ft. long, with a secondary step-up flat arch of the same length. The flame travel here is ample to provide smokeless operation at any commercial capacity, and the total extension is 10 ft. 6 in. to the gate.

In combining a chain grate with a boiler of the Wickes type, ample flame travel can be provided, and the arch can be set at a height corresponding to the capacity it is desired to obtain and according to the draft which will be available. Ordinarily, an extension of 13 ft. from the heating surface to the gate will be found sufficient for a 400-hp. unit such as is shown in Fig. 8.

How to Operate a Chain Grate without Smoke

Starting Fires—Feed in the coal until the grate is about half covered and the hopper is empty. If the hopper is fed by a chute, care should be taken not to let down too much coal at this time. When all the coal has passed under the gate, throw some fresh coals from another fire or some light wood kindling with a few pieces of waste on the coal and start a fire. Sprinkle a little coal over the fire at the gate and feed in slowly until the fire is inside of the gate, and let the stoker stand for a few minutes until all of the coal is ignited. This with the damper partly open. Then fill the hopper with coal through the chute and let the stoker run slowly until the arch gets heated up, after which the regular speed can be used with the damper wide open.

Carrying the Load—Adjust the thickness of the fire at the gate until the whole of the grate is covered. The average speed of the grate ought to be about 3½ in. per min. If live coal goes into the ashpit, run the fire thinner or slow down the stoker. Do not allow the back end of the grate to become bare of live coals, as it will interfere seriously with efficiency. Proper manipulation of the speed and of the gate will keep the grates covered. Do not become alarmed if a few incandescent particles drop into the ashpit. It will not affect the economy.

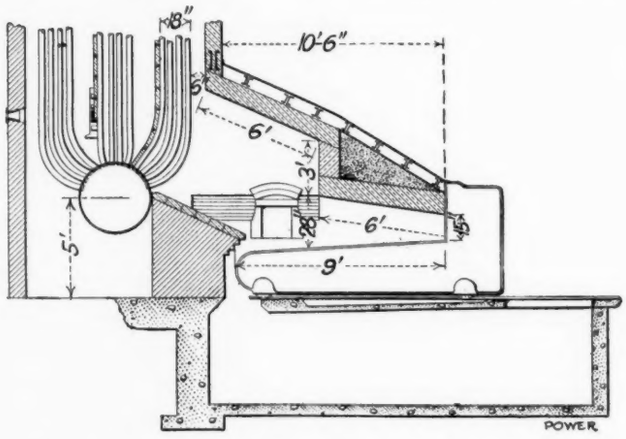


Fig. 7. An Erie City 312-Hp. Vertical Boiler and Inclined Illinois Chain Grate

To prevent clinkers from attaching to the side of the furnace, run a slice bar in along the sides occasionally.

Banking Fires—Let the fire burn short, raise the gate high and run in a heavy fire for two or three feet, according to the length of time the bank is to be carried. In doing this, run the hopper empty, lower the gate and partly close the damper.

Starting After a Bank—Raise the gate, break up the bank with a hook, pulling some of the fire out into the hopper. Lower the gate, fill the hopper with coal and

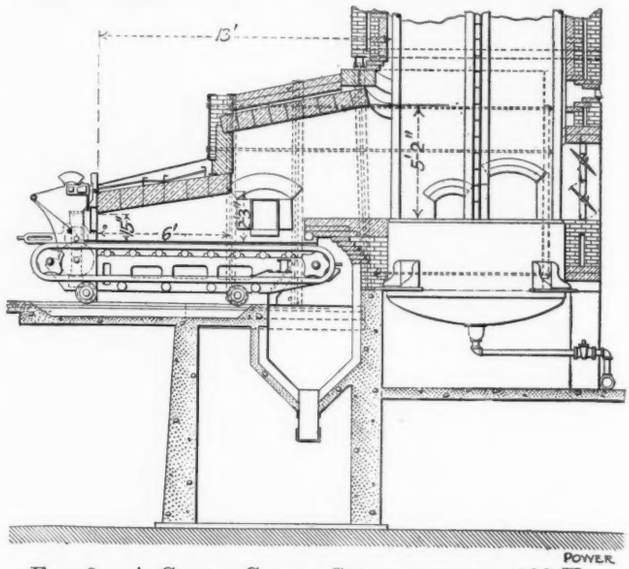


Fig. 8. A Green Chain Grate under a 400-Hp. Wickes Boiler

start the stoker slowly with partly opened damper until the arch gets hot. Closing the damper with a heavy fire on a chain grate will cause smoke, therefore if the demand for steam slackens, never close the damper until the fire has burned off the greater part of the volatile matter from the coal. Never stop the stoker for any length of time without first running the hopper empty, as the fire will burn back and injure the gate.

Errata—In the article "Chain-Grate Setting—II," of the Oct. 20 issue, Figs. 7 and 9 were transposed. The boiler in Fig. 7 is a Geary and that in Fig. 9 is an Erie City.

Cleaning the Caps of Water-Tube Boilers

After the caps on the headers of water-tube boilers have been removed for cleaning purposes, it is often hard to put them back again so that they will not leak. The difficulty is to get a tight metal-to-metal joint between the caps and the headers, as the slightest irregularity or unevenness holds the two surfaces apart sufficiently to cause leakage. It is common practice to endeavor to make the surfaces fit each other by smoothing them off with emery cloth. In doing the work it is convenient to tack the emery cloth upon a wooden disk, which is then made to revolve in a lathe or on a special machine constructed for the purpose, the cap being pressed up against the emery for a few moments until the surface is cleaned. The nuts may be treated in the same way.

The main objection to this procedure, apart from the necessity of frequently renewing the covering of the disk, is that the cap wears down at the outer edge faster than it does along the inner one, and hence it becomes rounded to a slightly convex shape, so that it will not touch the header anywhere except along a narrow line close to the inner edge. As a result, the contact is so poor that it is always hard, and sometimes impossible, to make the joint tight; and in the effort to stop the leakage the men some-

times screw the nuts up hard enough to strip the threads.

This trouble may be readily overcome by the following method, which is both simple and effective. A cast-iron faceplate is first prepared by resurfacing it in a planer. A mixture of oil and emery is then smeared over the faceplate, which is afterward revolved on a spindle, the cap to be treated being held up against it. In this way the cap can be ground down to a satisfactory surface, easily and quickly. If it does not become satisfactorily flat and true on the first application, it will be materially improved, and after the caps have been treated a few times they will fit the headers quite well. The object of finishing the faceplate on a planer is to provide it with a series of small, straight, shallow, parallel grooves, running across its surface from side to side. These serve to hold the emery and oil, so that a far better grinding action is obtained than could be had if the faceplate were smooth. No attempt should be made to exaggerate the tool marks, because they will usually be quite deep enough without doing so. Grooves turned in the faceplate on a lathe would not be useful for the purpose in mind, because they would run circularly around the plate, and therefore would not hold the emery and oil up against the cap satisfactorily. The ideal way to treat the plate would be, to provide it with shallow *radial* grooves; but the planing operation is far simpler, and it works quite well.

The same idea may be applied, if desired, to clean and true up the face of the header, where the caps rest against it; but in this case a special portable machine, operated by a motor of some kind or attached to a flexible shaft, must be used for rotating the grinding plate in contact with the header.—*The Travelers' Standard.*

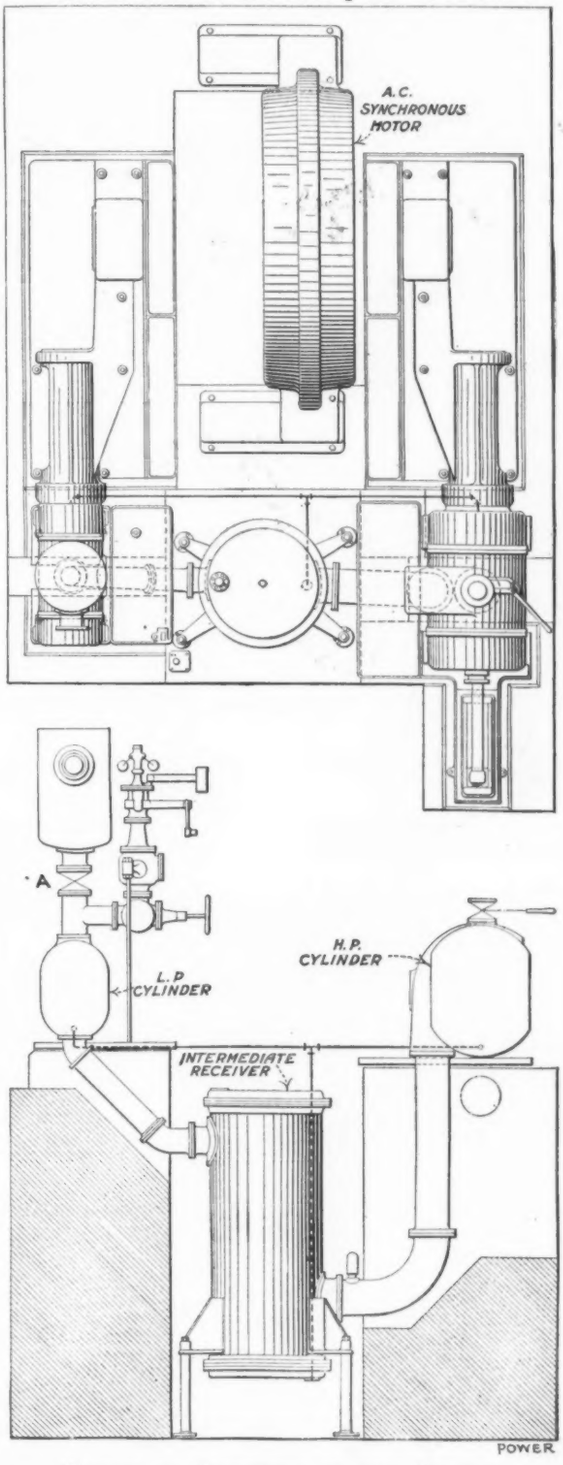
Air Compressor or Steam Engine

While at the works of the Nordberg Manufacturing Co. recently, the writer saw a two-stage air compressor almost ready for shipment to the Canadian Mining & Finance Co., of Timins, Ont. It was a standard machine, cross-connected, with the usual mechanically operated Corliss valves, having cylinders 22x37x31 in. The compressor is to be driven by a 25-cycle synchronous motor at 125 r.p.m. The unusual feature is that the machine is to be used as a steam engine in case of necessity, this being possible with the type of valve employed on Nordberg compressors.

It appears that the mining company operates the mine electrically, current being purchased from an outside water power. The principal equipment consists of a mine hoist, underground pumps, a concentrating mill, a compressor duplicating the one mentioned and a third compressor of different make. To guard against a possible breakdown in the transmission line, a steam reserve plant was considered necessary. Ordinarily, a full equipment of boilers, engines and generators would be needed, but with these compressors only the boilers are to be installed. Steam may be turned into the high-presure cylinder of the compressor, then delivered to the intermediate receiver and thence to the low-pressure cylinder as in any Corliss engine. The operation will be the reverse, the motor turning in the opposite direction will act as a generator. With a slight adjustment of the valves, the economy will be nearly as good as of an engine designed for the work.

To control the steam supply there is an automatic cut-off governor operated by an eccentric and also a belt from the crank shaft. The governor regulates the quantity of steam to the angle throttle valve connected to the discharge pipe of the compressor between the high-pressure cylinder and the receiver, as shown in the illustration. When steam is being supplied, the valve *A* is closed, and the same is true of the angle valve when the machine is acting as a compressor.

By this arrangement, enough current is generated to run the mine at reduced capacity and maintain it in operation until service from the water power is resumed.



PIPING OF CYLINDERS TO THE RECEIVER

Some Large Apparatus

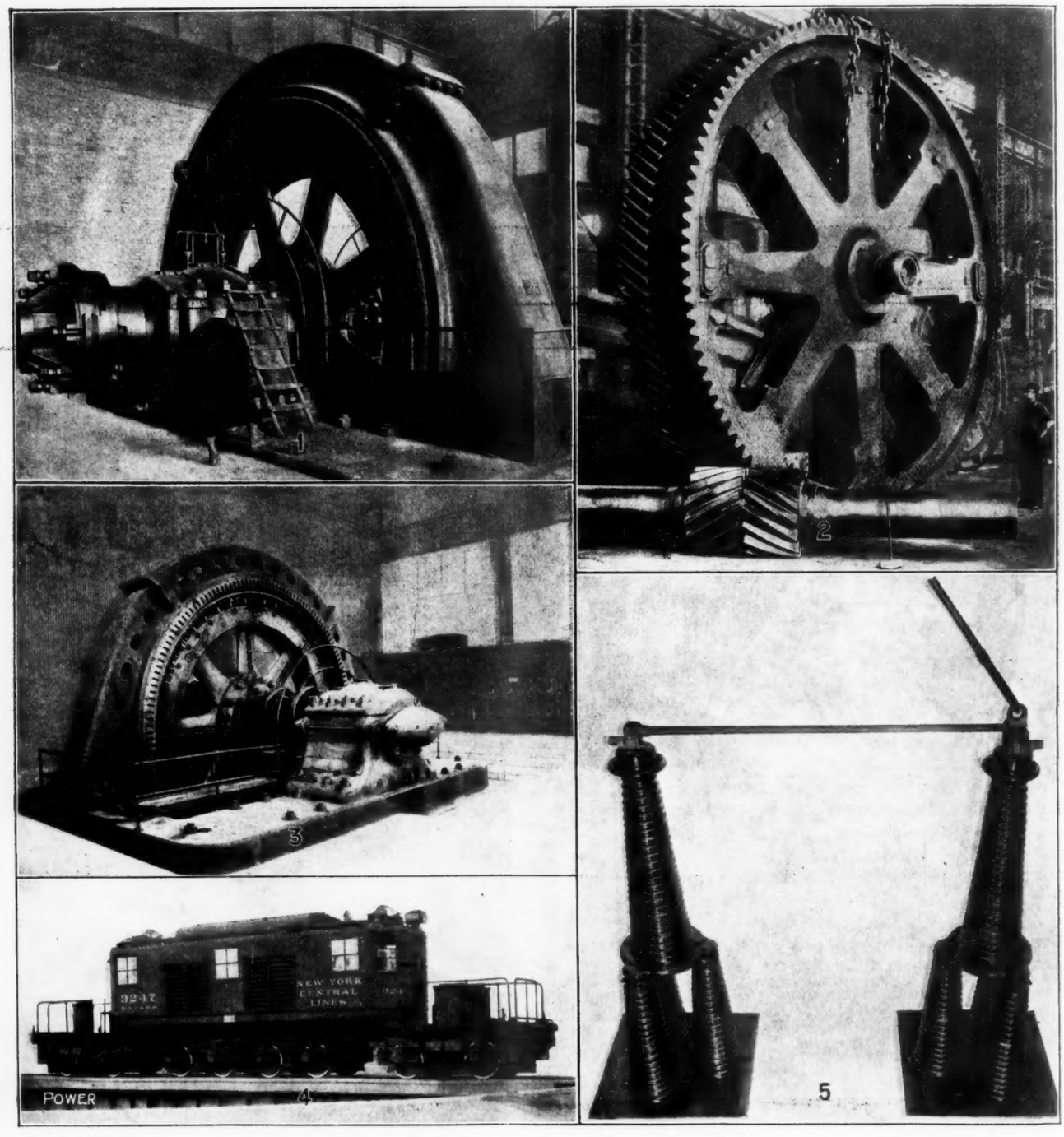


Fig. 1, this 6000-hp., 36-pole, 6600-volt induction motor drives an 18-in. continuous-billet mill at the Indiana Steel Co.'s plant, Gary, Ind. It has a speed of 83 r.p.m. Fig. 2, a 232-in. pitch diameter William Tod Co.'s gear with 116 teeth, 42-in. face. The pinion is of 30-in. pitch diameter, 15 teeth, and has a 42-in. face. It is forged and carries two 13-ft. 6-in. flywheels weighing 50 tons. The total weight of the gear and pinion is 85 tons. This is the largest gear with machine-cut double-helical teeth ever made in this country. The helix is at a 30-deg. angle. Fig. 3 is a 6500-hp., 6600-volt induction motor of the slip-ring type. It is provided with a switch for changing the number of poles to change the speed. The motor may be run as a 28- or 56-pole machine with speeds respectively of 107 and 53 r.p.m. It is used in the 60-in. universal plate mill of the Indiana Steel Co.

Fig. 4 is a 100-ton electric locomotive built for service on the electrified section, the Hudson division, of the New York Central & Hudson River R.R. Ten of these have been ordered. This is the most powerful electric passenger locomotive ever built, and will exert sufficient tractive effort to haul a train weighing 1000 tons at a speed of 60 miles an hour.

Fig. 5 shows a 150,000-volt, 300-ampere disconnecting switch with corona caps and tubular blade. The height of the switch is 5 ft., 11$\frac{1}{16}$ in. The distance between the centers of the top insulators is 4 ft. 8 in. This apparatus, with the exception of the gear and pinion, is the output of the General Electric Co.

Steam Engineers' License Law of Detroit Amended

The common council of Detroit recently adopted an amendment to the steam engineers' license law as proposed by J. C. McCabe, chief boiler inspector. The amendment provides for free annual renewal of licenses. Under the newly amended ordinance all applicants for license must pay a fee of $1 when making application. If they pass the required examination and are awarded a first- or second-class license, they must pay an additional fee of $2. If a third- or fourth-class license is obtained the extra fee is only $1. All licenses are renewed without charge if application for renewal is made within 10 days after expiration. Formerly there was a renewal fee.

There are about 2700 licensed engineers in Detroit, of which some 2000 will benefit by the free-renewal amendment. About 1200 applications for licenses are received each year.

An ordinance has also been passed to regulate the use, handling, storage and sale of inflammable liquids. Detroit is the first city to pass such an ordinance, which closely follows the code of the National Board of Underwriters. Mr. McCabe, the chief boiler inspector, is to have charge of the inspection of all devices used in the storage and handling of these liquids.

York Power Companies Merge

The City Council of York, Penn., has consented to the merging of the Merchants' Electric Light, Heat & Power Co. with the Edison Electric Light Co. The latter company has applied to the State Public Service Commission for a certificate of approval.

The Merchants' company will forfeit a $5000 bond to the city, this being one of the provisions in its charter. For years these two companies have been rivals in York and the vicinity. The field is now controlled by the Edison company.

Goes Perpetual Motion One Better

The following clipping from the *Kansas City Post* of Sept. 5 should interest power-plant men:

An engine that runs itself on its own power, developing energy to operate machinery, has been invented in this city. The inventor has been working for five years on his self-operating engine, and now has it near perfection. A few alterations are to be made. These will increase its efficiency.

The engine is run by compressed air, making its own pressure as it runs. The exhaust from the cylinders returns through a series of eight-port automatic valves, to a large steel pressure tank. This tank is a double affair, there being a smaller tank within the larger one.

An air space of 6 in. intervenes between the two tanks. Into the air space the exhaust from the cylinders is forced, the action being such that the nitrogen gases are separated from the oxygen and, forming a lighter gas, rises to the top of the tank, at the same time creating a pressure which forces the fresh air down through the inner tank and back into the engine, which is operated by this pressure.

The only serious feature of the foregoing is the fact that men do actually attempt to get something for nothing, mechanically.

Electricity in the Steel Industry—The magnitude of electrical application in the iron and steel industry is not without interest or surprise. The data show that the installed horsepower of motors used last year by 62 steel companies was more than 1,250,000 and the number of motors in service was 45,512. More startling was the amount of energy generated and purchased by these companies, 1,641,564,000 kw.-hr. This is more than one-tenth of the total output of the central stations of the United States in 1912, and the rating of motors is almost equal to that receiving energy from the entire central-station industry of the country seven years ago. One plant alone used more electricity than was generated by the Edison systems of Brooklyn and Boston combined. When, as has been predicted, electricity shall have supplanted steam entirely as motive power, the electrical needs of the steel industry will be enormous. Only three of the companies purchase electrical energy. An abundant opportunity exists here for enterprising central-station managers to add to this number.—"Electrical World."

Carnegie Institution Reorganizes Stationary Engineering Department

The School of Applied Industries of the Carnegie Institute of Technology offers a course in the theory and practice of power generation, which covers the operation of steam engines, steam boilers, gas engines, electric generators, motors and all auxiliary apparatus. While this department has been in existence for several years, it has recently undergone a reorganization for the purpose of increasing its efficiency and effectiveness in meeting the growing demand for instruction of this nature.

Not only is a straight night course offered, but a special course has been arranged to benefit the man who alternates day and night turn. This is special only as regards time, and is identical in every way to the regular night course. It will allow the engineer to attend school six to eight hours per week on his off turn. It will also allow any engineer, employed at night only to attend school for a short period of six to eight hours per week, during the day.

As far as is possible and practicable, students are instructed from actual engines, boilers, and models. Mathematics is eliminated or simplified in demonstrations, at the beginning of the course, and later taken up as the student gains knowledge of this important subject.

There are available for demonstration and test five different types of boilers, from 60 to 350 hp.; five different types of steam engines, from 10 to 750 hp.; nine different types of internal combustion engines, from 1½ to 550 hp.; in addition to a large variety of auxiliary apparatus. All of these, with the exception of one gas engine, are located in the new Machinery Hall.

The course is laid out to cover a period of four years, and consists of work on the above mentioned equipment, accompanied with numerous lectures and problems. Other subjects given during the four years are mathematics, drawing, machine shop practice, elementary electrical engineering, chemistry, and English.

No written examination for entrance to this course is required, but each applicant must present himself to the dean of the School of Applied Industries for personal interview, and must show satisfactory evidence of his natural ability and tendency for work of this nature. Preference will always be given to men already employed in some power station.

A student registering under this alternate day and night arrangement, as well as for the regular night class, shall do so as a regular night student. The total tuition for night courses is $16 a school year for residents of Pittsburgh, and $18 for non-residents.

Engineers will be gladly furnished any further information by the registrar, Carnegie Institute of Technology, Pittsburgh, Penn.

Arkansas Power Co. Expands

The Arkansas Light & Power Co. is planning extensive improvement, and in order to finance these it has filed a mortgage in favor of the Guaranty Trust Co., of New York, securing payment of its two-year 6 per cent. notes. It is specified that the latter are not to exceed $1,000,000.

The company operates plants at Malvern, Camden, Arkadelphia, Magnolia and other points in the state. It will not only improve its present plants, but will add to the number, and is considering the advisability of erecting a power dam at Caddo Gap.

Pacific Coast Power Notes

The quarterly report of State Engineer Lewis of Oregon, just made public, shows 173 permits issued for the appropriation of water for power purposes. These permits cover works to cost $5,000,000 in the development of 30,460 hp., constructing 230 miles of pipe lines, etc.

George W. Holcomb, Portland, Ore., proposes to develop 10,255 hp. from the Clackamas River; the Rogue River Public Service Corporation contemplates the development of 11,989 hp. on the Rogue River and J. E. Johnson, Drewsey, has secured a permit to develop 3409 hp. with the waters of the Malheur River. The Siletz Power Co., Portland, Ore., has a filing on the Siletz River for the development of 2576 hp.

Plans are being prepared under the supervision of Major J. B. Cavanaugh, Seattle, for the construction of a $50,000 power house for the Lake Washington Canal project of the War Department. There are also plans for the construction

of five operating houses and twenty 30-ft. reinforced-concrete light standards for the canal locks.

A reorganization of the Yosemite Power Co. has been made at Sacramento, Calif., by the consolidation with the Tuolumne Light & Power Co., the Tuolumne Water Co. and the La Grande Water Co.

Recent Court Decisions

Digested by A. L. H. STREET

Damages Recoverable for Personal Injury—$4900 was not an excessive award for injury to an employee of a power company, sustained by him in consequence of negligence imputable to the company, where it appeared that he was 23 years old, had previously earned $2 a day, lost the sight of one eye as a result of the injury, and had the sight of the other eye impaired, according to a recent decision of the Maine Supreme Judicial Court handed down in the case of Rollins vs. Central Maine Power Co., 91 "Atlantic Reporter" 937.

Duty to Maintain Water Glass—An employer's negligent failure to replace a broken water glass on a stationary boiler after being informed of the break may be found to be the direct cause of death of the fireman, caused by explosion of the boiler, although the latter could have determined the stage of the water in the boiler by using water cocks with which the boiler was equipped. "Where machinery is equipped with more than one safety appliance, and one of these appliances is better adapted to use by unskilled persons than the other, it is the duty of the master to use reasonable care to keep all of the appliances in working order, so that the servant may have all the protection that the conditions surrounding him reasonably permit. And the reasonable presumption is that an employee like Moreland (the fireman) would depend on the water glass more than on the water cocks." (Moreland's Administratrix vs. Hough & Spradlin, 169 "Southwestern Reporter," 467, Kentucky Court of Appeals.)

NEW PUBLICATIONS

FUEL ECONOMY AND CO_2 RECORDERS. By A. R. Maujer and Charles H. Bromley. Published by McGraw-Hill Book Co., New York. Cloth, 189 pages; 8¼x5½ in. Price, $1.50

The contents of this book first appeared in the "Engineers' Study Course" in "Power." The aim of the authors has been to give to practical operating men a simple yet reasonably thorough treatment of the subjects of combustion, coal analysis, flue-gas analysis, heat losses, draft, boiler testing, feedwater treatment and CO_2 recorders.

That the "Study Course" was so well received would indicate that the book will fill a want long felt by the progressive operating engineer seeking to better his boiler-room conditions.

PRACTICAL MATHEMATICS FOR ENGINEERS. By F. Hoovenden. Published by D. Van Nostrand Co., New York. Cloth; 144 pages. 5½x8 in. Price $1.

This book is intended chiefly for marine engineers and apprentices following marine engineering. As the book was written in Great Britain, the money values, etc., used are English; the text aims to coach the student for a Board of Trade certificate.

Beginning with numbers, the subject is followed, as in the usual arithmetic through to mensuration. Pages 98 to 134 are devoted to problems in mechanics, the nature of the problems being associated almost exclusively with marine engineering. The last few pages contain answers to many of the problems given.

HIGH-POWER GAS ENGINES. By H. Dubbel. Translated from the German and expanded by F. Weinreb. Published by D. Van Nostrand Co., New York, 1914. Size 7½x11 in.; 197 pp.; 436 illustrations. Price $5 net.

This is a book intended essentially for the designer. As such, much of the elementary and general matter usually found in gas engine books has been omitted and the text devoted to the special problems encountered in the large gas engine. German practice predominates, as might be expected, not only from the origin of the book, but because the Germans have been pioneers in developing the large gas engine. This is supplemented by present English practice and a few American designs. The illustrations are good and assist greatly in a clear understanding of the text.

INDICATOR DIAGRAMS FOR MARINE ENGINEERS. By W. C. McGibbon. Published by D. Van Nostrand Co., New York. Third edition. Imitation leather. 182 pages; 9¼x8 in.; indexed, with list of illustrations. Price, $3.

For marine engineers this is the best work on the indicator that has come to our attention. The author has met his endeavor to give a complete treatment of the subject and at the same time avoid elaborate mathematical calculations. It is sufficient to say that the book does not neglect any important phase of steam-engine indicator practice, and this may be appreciated when it is known that there are 159 illustrations, mostly of diagrams thoroughly considered. The diagrams appear in white on a black background.

The marine engineer will find this a most useful book.

ELEMENTARY MATHEMATICS FOR MARINE ENGINEERS. By J. W. M. and R. M. Sothern. Published by D. Van Nostrand Co., New York. Cloth. 174 pages; 5½x8 in. Price $1.

The field of this book is fully told in the title. The volume starts with elementary algebra, the first seventy-six pages being devoted to this subject, giving it a reasonably thorough treatment. Logarithms follow. The third section is rather unusual for a book on elementary mathematics for practical men, in that it is devoted to a study of entropy.

The author covers the subject well for the purpose and, of course, finds many opportunities to put to use the student's knowledge of logarithms as offered by the previous chapter. There are nineteen temperature-entropy diagrams, including three which are large and inserted so that for the principal problems diagrams are shown and assist the student in following this much disliked subject. The last chapter is a short treatment of plane trigonometry.

A dollar is a fair price for the book, and a marine engineer especially would not regret the investment.

HEAT ENGINES. By John R. Allen and Joseph A. Bursley; second edition. Published by the McGraw-Hill Book Co., New York, 1914. Size 6x9 in., 320 pp.; 185 illustrations. Price $3.

The scope of this book is somewhat broader than might be inferred from the title, including heat, elementary thermodynamics, properties of steam, calorimeters, combustion and fuels, boilers, auxiliaries, steam engines, valve gears, governors, condensers and air pumps, steam turbines, gas engines and oil engines. Limitations of space have precluded a special study of any of these subjects, but enough is given to afford the reader a general working knowledge of each. Bearing in mind its purpose, namely, a textbook for engineering students, it appears to meet the requirements, and, moreover, is one of the few college textbooks suited to outside study without the aid of the instructor. For such use, the small amount of higher mathematics contained in the text need not prove a serious obstacle. A number of practical examples at the end of each chapter add to a clearer understanding of the subjects discussed.

In revising the book, the authors have rewritten much of the text, brought up to date the chapters on steam turbines and gas engines, and added descriptions of such later subjects as the uniflow engine and the Humphrey pump.

Small Charge for "Consular and Trade Reports"—The Department of Commerce has announced that to meet the constantly increasing demands which were far in excess of the edition authorized by Congress for free distribution, a subscription price of $2.50 a year was fixed for the "Daily Consular and Trade Reports," effective July 1, 1914. Under this plan the charge, which is less than the cost of printing and paper, permits all firms and individuals who desire the publication to obtain it promptly. Many persons who were formerly unable to obtain the reports because of the limited edition fixed by law, may not yet be aware of the opportunity to subscribe, and thus have access to the commercial information gathered by the Federal Government from all the countries of the world for the benefit of American business houses. Subscriptions for the publication are received by the Superintendent of Documents, Government Printing Office, Washington, D. C., at $2.50 per annum mailed daily, and $6 per annum for cloth-bound quarterly volumes, with index.

ENGINEERING AFFAIRS

Boston Edison Co. Annual Meeting—The annual meeting of the Boston Edison Co. Section of the National Electric Light Association was held in the assembly hall of the Engineers' Club, Tuesday evening, Oct. 20, at 8 o'clock. A lecture of special interest to members, on "The Hydraulic Plant of the Mississippi River Power Co. at Keokuk, Iowa," was given by H. T. Edgar, of the Stone & Webster Corporation. On the completion of the lecture, stereopticon illustrations of the plant were shown by D. L. Galusha, of the same corporation.